ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES

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DR. NAVJOT SINGH

DEPARTMENT OF RADIODIAGNOSIS
DAYANAND MEDICAL COLLEGE AND HOSPITAL
LUDHIANA, PUNJAB

DECLARATION BY THE CANDIDATE

I hereby declare that the thesis entitled "**ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES**" submitted towards partial fulfillment of the requirements for the award of **MD in Radiodiagnosis** degree to BFUHS is a compilation of original work carried out by me under the supervision of **Dr. Kamini Gupta,** Professor, Department of Radiodiagnosis, **Dr. Archana Ahluwalia,** Professor, Department of Radiodiagnosis. No part of this thesis has formed the basis for the award of any degree previously.

_____

DR. NAVJOT SINGH
Department of Radiodiagnosis,
Dayanand Medical College & Hospital,
Ludhiana, Punjab

Date:

Place:

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This is to certify that the work incorporated in this thesis entitled "**ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES"** has been carried out by **Dr. Navjot Singh** under our direct supervision. The data incorporated in this thesis is original and genuine and has been carried out by the candidate himself.

Signature of Supervisor

Dr. Kamini Gupta
Professor
Department of Radiodiagnosis
DMC&H, Ludhiana

Signature of Co-Supervisors

Dr Archana Ahluwalia
Professor
Department of Radiodiagnosis
DMC&H, Ludhiana

Date:

ENDORSEMENT BY THE HEAD OF THE INSTITUTE

This is to certify that the thesis entitled "**ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES"** is a bonafide research work done by **Dr. Navjot Singh** under the supervision of **Dr. Kamini Gupta,** Professor, Department of Radiodiagnosis, **Dr. Archana Ahluwalia,** Professor, Department of Radiodiagnosis, in this institution.

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Dr. Sandeep Puri
Principal
DMC&H, Ludhiana

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Dr. Navjot Singh
Department of Radiodiagnosis,
Dayanand Medical College & Hospital,
Ludhiana, Punjab

Date:

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Dedicated

to

my Family

&

Teachers

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ABBREVIATIONS

MDCT	Multidetector Computed Tomography
CT	Computed Tomography
PC	Peritoneal Carcinomatosis
PTB	Peritoneal Tuberculosis
TB	Tuberculosis
MRI	Magnetic Resonance Imaging
FDG-PET/CT	Fluorodeoxyglucose-Positron Emission Tomography/ Computed Tomography
MPM	Malignant Peritoneal Mesothelioma
CT-OR Sign	Computed Tomography-Omental Rim Sign

ABSTRACT

Introduction: Peritoneal diseases includes peritoneal carcinomatosis, peritoneal tuberculosis, pseudomyxoma peritonei, peritoneal mesothelioma, lymphoma and infective/ inflammatory peritonitis. On Multi-detector contrast enhanced CT, normal peritoneum is a thin membrane and is hardly noticeable. The involvement of peritoneum in various diseases causes its thickening which become easily detectable on cross-sectional imaging. Most of the peritoneal diseases have similar CT appearance, however based on certain CT patterns, benign peritoneal diseases can be differentiated from malignant ones and underlying pathology may be defined.

Aims & Objectives: 1. To assess the role of multi detector contrast enhanced CT in evaluation of peritoneal diseases. 2. To predict the etiology of peritoneal diseases and correlate with histopathology, wherever possible.

Materials and methods: A prospective longitudinal study of 35 patients (11M; 24F, Age range:-16-77years) undergoing multi-detector contrast enhanced CT for peritoneal diseases, at the Department of Radiodiagnosis, Dayanand Medical College &Hospital ,Ludhiana, during a period of one year.

Results: Out of 35 cases, 21 were of peritoneal carcinomatosis and 14 of peritoneal tuberculosis. Smooth and uniform peritoneal thickening was more frequently seen in peritoneal tuberculosis ($p < 0.001$) and irregular peritoneal thickening were more frequently seen in peritoneal carcinomatosis ($p < 0.001$). Peritoneal micro-nodules(<0.5mm) were more frequent in peritoneal tuberculosis (p value-0.018) and mixed in peritoneal carcinomatosis (p value-0.001). Homogenous peritoneal nodular enhancement more frequent in peritoneal tuberculosis (p value-0.001) and heterogenous enhancement in peritoneal carcinomatosis (p value-0.001) Omental smudginess was more common in peritoneal tuberculosis patients (p value 0.012) while omental nodularity is more commonly seen in 61.9% of peritoneal carcinomatosis patients.

Conclusion: CT findings like omental smudginess, smooth homogenous peritoneal thickening, peritoneal micronodules and homogenous peritoneal nodular enhancement can be useful in favouring the diagnosis of peritoneal tuberculosis over peritoneal carcinomatosis.

Keywords: Multi-detector Contrast enhanced Computed Tomography (MD-CECT), Peritoneal carcinomatosis (PC), Peritoneal tuberculosis (PTB).

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INTRODUCTION

The peritoneum is a mesothelial lining covering the abdominal cavity (parietal peritoneum) and intraperitoneal organs (visceral peritoneum).[1]

The visceral peritoneum covers the intraperitoneal organs (stomach, jejunum, ileum, transverse colon, sigmoid colon, liver, and spleen), omentum, and mesenteries. The parietal peritoneum lines anterior, lateral, and posterior abdominal walls; under surface of diaphragm; anterior surface of retroperitoneal viscera (duodenum, ascending and descending colon, pancreas, and portions of adrenal glands and kidneys); and pelvis. The purpose of the peritoneum is to provide a frictionless surface over which viscera can move. It also serves as a site of fluid transport.[2]

The peritoneal cavity is a potential space between parietal peritoneum, which lines abdominal wall, and visceral peritoneum, which envelopes the abdominal organs. Peritoneal cavity contains a small amount of fluid, which circulates under the influence of negative pressure generated by the diaphragm, gravity and bowel peristalsis. This natural flow pattern determines the route of spread of disease.[3] In men, the peritoneal cavity is closed, but in women, it communicates with the extraperitoneal pelvis exteriorly through fallopian tubes, uterus, and vagina.

Peritoneal ligaments are double layers or folds of peritoneum that support a structure within the peritoneal cavity.

The peritoneal ligaments (coronary, gastrohepatic, hepatoduodenal, falciform, gastrocolic, duodenocolic, gastrosplenic, splenorenal, and phrenicocolic) and mesenteries (transverse mesocolon, small bowel mesentery, and sigmoid mesentery) subdivide the peritoneum into interconnected compartments that dictate the location and routes of spread of primary and secondary malignancies and infection within the peritoneal cavity.[4]

Omentum is a mesentery or double layer of peritoneum that extends from stomach and duodenal bulb to adjacent organs. The lesser omentum, which is made of two contiguous components called the gastrohepatic and hepatoduodenal ligaments, attaches stomach and duodenal bulb to the liver. The greater omentum is attached to the stomach and hangs like an apron from the transverse colon.

Mesentery is a double layer of peritoneum that encloses an organ and connects it to the abdominal wall. The mesenteric contents include blood vessels, lymph nodes, nerves, and fat. The most mobile parts of intestine have a mesentery (eg, small bowel attached to the retroperitoneum), and the retroperitoneal portions of colon may contain remnant mesocolon, as a result of its failure to absorb embryonic mesentery.

Peritoneal reflections are the lines of folding where the visceral peritoneum becomes the parietal peritoneum; and peritoneal recesses are spaces formed by these reflections. The subphrenic submesothelial lymphatics communicate with subpleural lymphatics and provide majority of the lymphatic clearance from the peritoneal cavity.[5] The subphrenic peritoneal surfaces and the visceral peritoneal surface of liver and spleen become major sites of dissemination of primary and secondary peritoneal malignancies.

The subphrenic space is separated into right and left by the falciform ligament.

The right subphrenic space is limited posteriorly and inferiorly by the right coronary ligament, which forms the boundary of bare area of liver. The left subphrenic space is not limited by the triangular and coronary ligaments of left hepatic lobe because they are small and anatomically insignificant. The phrenicocolic ligament, which is a peritoneal fold extending from the splenic flexure of colon to the diaphragm, limits the spread of peritoneal processes in left upper

quadrant because it partially separates perisplenic space from left paracolic gutter.[4]

Primary peritoneal tumors are defined as tumors with primary manifestation in the peritoneum in the absence of a visceral site of origin.[6]

Classification of Primary Tumors of the Peritoneum
Mesothelial tumors
Peritoneal malignant mesothelioma
Well-differentiated papillary mesothelioma
Multicystic mesothelioma
Adenomatoid tumor
Epithelial tumors
Primary peritoneal serous carcinoma
Primary peritoneal serous borderline tumor
Smooth muscle tumor
Leiomyomatosis peritonealis disseminate
Tumors of uncertain origin
Desmoplastic small round cell tumor
Solitary fibrous tumor

Classification of Secondary Tumors and Tumor like Lesions of the Peritoneum
Metastatic neoplasms
Carcinomatosis
Pseudomyxoma peritonei
Lymphomatosis
Infectious and postinfectious lesions
Tuberculous peritonitis
Disseminated histoplasmosis
Inflammatory pseudotumor
Miscellaneous
Endometriosis
Gliomatosis peritonei
Osseous metaplasia
Cartilagenous metaplasia
Melanosis

Common peritoneal diseases in India include peritoneal carcinomatosis and peritoneal tuberculosis.

Peritoneal carcinomatosis (PC) is defined as intraperitoneal dissemination of any tumor which is not originated from the peritoneum itself.[7]

On Multi-detector contrast enhanced CT, normal peritoneum is a thin membrane and is hardly noticeable. The involvement of peritoneum in various diseases causes its thickening which become easily detectable on cross-sectional imaging.

Most of the peritoneal diseases have similar CT appearance, however based on certain CT patterns, benign peritoneal diseases can be differentiated from malignant ones and underlying pathology may be defined.

Peritoneal carcinomatosis (PC) is most commonly seen in abdominopelvic malignancies. Ovarian cancer is the most commonest

abdominopelvic malignancy with peritoneal diseases, in which approximately 70% of patients have peritoneal involvement at the time of diagnosis. It is followed by colorectal carcinoma (31%), pancreatic cancer and stomach cancer. Other malignancies include hepatocellular carcinoma, gallbladder carcinoma, renal cell carcinoma, transitional cell carcinoma, endometrial and cervical cancers. Extra-abdominal malignancies such as carcinoma breast, carcinoma lung and malignant melanoma involve the peritoneal cavity through haematogenous spread.[3,8] Characterization of different CT patterns of peritoneal carcinomatosis is also important as there is predilection of different malignancies for having different patterns of peritoneal diseases.[9-11]

Many non-neoplastic and other neoplastic conditions may mimic Peritoneal carcinomatosis (PC), such as tuberculosis, splenosis implant, peritoneal lymphomatosis, pseudomyxoma peritonei and primary peritoneal mesothelioma.[7,12]

Peritoneal carcinomatosis (PC) have multiple manifestations on CT including fibronodular stranding, nodules, plaques, masses and mesenteric thickening which may produce a pleated or stellate pattern.[1] The imaging patterns of diffuse malignant peritoneal mesothelioma include thickening of pleura, peritoneum/mesentery, nodules of various sizes and shapes, mesenteric or omental infiltrations, omental cake, ascites, bone destruction, and lymphadenopathy.[13]

Tuberculosis (TB) is one of the world's deadliest diseases and peritoneal tuberculosis (PTB) is one of the commonest manifestations of abdominal TB.[14,15]

The common occurrence of mesenteric micro- or macro-nodules in tuberculous peritonitis appears to be because tuberculous peritonitis develops from rupture of mesenteric lymph nodes seeded by hematogenous or lymphatics routes from primary lesion sites.[16] Peritoneal TB is a close mimicker of peritoneal carcinomatosis and it

can be challenging to differentiate the two clinically as well as on imaging.[17]

Multi-detector CT with multi-planar reformation allows accurate assessment of complex anatomy of peritoneal cavity and helps in understanding the pathologic processes.

However, CT still poses problems, such as low sensitivity for detecting minimal peritoneal diseases, especially when the lesions are less than 1 cm in diameter.[18]

Appropriate determination of extent of peritoneal diseases changes the staging of disease, treatment plan and prognosis. [3]

Though the imaging features of peritoneal diseases overlap, MDCT is currently a useful tool to assess the extent of peritoneal diseases and to differentiate benign from malignant diseases.

CT is the imaging modality of choice for evaluating patients with diffuse abdominal disorders and for staging malignancies.[19,20] Ascites is a common finding in peritoneal carcinomatosis, the discovery of new-onset ascites should lead to a careful search for findings that would indicate a malignant etiology.

Loculation of ascitic fluid is one of the most helpful features.[21] Thickening, nodularity, and intravenous contrast material enhancement of the peritoneum are also suggestive of a malignant process. In a patient with a known primary malignancy who lacks ascites, careful inspection of anatomic regions of peritoneal cavity where stasis of peritoneal fluid occurs is important during staging CT because peritoneal tumors can be subtle and difficult to identify, especially when ascites is not present. The pouch of Douglas or retrovesical space, ileocecal region, paracolic gutters, subhepatic space, right subdiaphragmatic space, and root of small bowel mesentery are important sites of occult tumor.[22]

Conventional CT has a low sensitivity (60%–79%) for the detection of peritoneal carcinomatosis.[23,24] In more recent studies, in which helical CT scanners were used, CT demonstrated improved overall sensitivity (85%–93%) but poor sensitivity (25%–50%) for detection of tumor implants less than 1 cm (25). In contrast, MR imaging has been shown to have better sensitivity (85%–90%) than CT for the detection of tumor nodules less than 1 cm and an overall sensitivity for all peritoneal tumor nodules of 84%.[25] The reported sensitivities of FDG PET/ CT for the detection of peritoneal carcinomatosis are 78%–100%, with the highest sensitivities in patients with clinically suspected recurrent tumor because of elevation in tumor markers.[26-28] However, similar to CT and MR, PET/CT is limited by spatial resolution. Consequently, subcentimeter lesions may not demonstrate sufficient uptake to be visible at PET/CT. At PET/CT, metastatic foci appear as round, oval, or globular areas of increased activity. One of the most important pitfalls in the interpretation of peritoneal diseases is the presence of normal physiologic activity within the bowel, liver, and spleen, an imaging finding that can limit visualization of metastatic lesions or can be misinterpreted as pathologic activity when there is misregistration of PET and CT images.

AIMS AND OBJECTIVES

1. To assess the role of multidetector contrast enhanced CT in evaluation of peritoneal diseases.
2. To predict the etiology of peritoneal diseases and correlate with histopathology, wherever possible.

REVIEW OF LITERATURE

H K Ha et al (1996) retrospectively reviewed CT scans in 135 patients of tuberculous peritonitis (n=42) and peritoneal carcinomatosis (n=93) with documented omental, mesenteric, or peritoneal pathology. CT findings were evaluated in each group of patients for the morphologic appearance of mesenteric or omental abnormalities as well as for visualization of the spleen and liver, the lymph nodes, and ascites. Statistical comparisons were performed to adjust for the differences in CT findings between the two groups. Using multivariate analysis, they calculated the sensitivity of CT for predicting tuberculosis peritonitis and peritoneal carcinomatosis as 69% and 91% respectively.[29]

E Rodríguez et al (1996) performed a retrospective study to review the CT scans in 19 patients known to have PTB and compared with scans in 19 patients known to have PC. CT images were evaluated for thickening (smooth versus irregular), enhancement, presence of nodules, and site of involvement on the parietal peritoneum, existence of omental caking, nodules, and smudged patterns in the omentum, mesentery, and gastrocolic ligament, presence, distribution, and loculation of ascites were evaluated. The most useful CT findings for distinguishing PTB from PC were observed in the parietal peritoneum. The presence of a smooth peritoneum with minimal thickening and pronounced enhancement suggested PTB, whereas nodular implants and irregular peritoneal thickening suggested PC.[30]

Ling-xia Jiang et al(2004) retrospectively reviewed the computed tomography (CT) findings in 18 cases with tuberculous peritonitis clinically simulating advanced ovarian cancer but pathologically proved otherwise .1. Masses with solid and cystic structures were found in 6 cases and tumor-like flakes were found in 7 cases in the adnexal regions. The solid components and tumor-like flakes were moderately to markedly enhanced with dynamic CT scanning. 2. The peritoneum was smooth and slightly thickened in 10 cases; irregular thickening was seen in 4 cases, and patches of calcification in 3 cases. Thickened

peritoneum with pronounced enhancement was noted in 7 cases. 3. Omentum with flake-like thickening was noted in 11 cases, coarse reticulate thickening in 2 cases and omental cakes in 2 cases. 4. Nodular and stripe-like thickening of the mesentery was noted in 16 cases. 5. Ascites was present in all of the 18 cases, being encapsulated in 14 of them. 6. Lymphadenopathy was seen in 9 cases, all at located in the diaphragmatic levels. Enhancement of the lymph nodes was marked in 8 of the 8 patients examined. They appeared as ring-like (> 1 cm in diameter) or uniform (<or= 1 cm in diameter) enhancement.[31]

Chen-Hsuan Wu et al (2011) retrospectively reviewed and evaluated seventeen patients diagnosed as having peritoneal TB between July 1986 and December 2008 at the Obstetrics and Gynecology Department of our hospital with the initial presentation simulating advanced ovarian cancer with patients' ages ranged from 24 years to 87 years (median, 38 years). Ten of 17 patients (60%) were younger than 40 years. All patients except one had elevated serum cancer antigen-125 levels with a mean of 358.8 U/mL (range, 12-733 U/mL). Computed tomographic (CT) scans showed ascites with mesenteric or omental stranding in all (100%), enlarged retroperitoneal lymph nodes in six (35.3%), and an adnexal mass in three (17.6%). Abdominal paracentesis was performed in seven cases, in which the findings revealed lymphocyte-dominant ascites without malignant cells. Surgical intervention by laparotomy was performed in 13 cases (76%) and by laparoscopy in three cases (18%), and a CT-guided peritoneal biopsy was performed in one case (6%) and final pathological examination confirmed a diagnosis of peritoneal TB. All patients responded to anti-TB treatment. He concluded that TB should be considered in a relatively young female with nonspecific symptoms of abdominal distension and wasting, as well as lymphocytic ascites without malignant cells. Laparoscopy or a mini laparotomy to obtain tissue samples for frozen-section analysis may be the most direct and

least-invasive approach for a diagnosis, thus avoiding unnecessary extended surgery in these patients.[32]

Aphinya Charoensak et al (2012) studied abdominal CT scan in proven cases of TB peritonitis and P.C. retrospectively. CT findings were assessed for ascites, abnormalities of peritoneum, omentum, and mesentery, abdominal lymphadenopathy. Statistical differences of CT findings between two diseases were analyzed using Chi-square or Fisher's exact test. Smooth and uniform peritoneal thickening was more frequently seen in tuberculous peritonitis ($p < 0.001$), but irregular peritoneal thickening and peritoneal nodules were more frequently seen in peritoneal carcinomatosis ($p < 0.001$). Type of omental abnormalities significantly differed between two diseases ($p < 0.001$). Smudge type was more commonly found in tuberculous peritonitis, while nodular and cake types were more commonly detected in peritoneal carcinomatosis. Lymph nodes size < 1 cm and location of lymph nodes at peripancreatic region were more frequently identified in tuberculous peritonitis, whereas lymph nodes size > or = 1 cm and contour abnormality of the liver or the spleen were more frequently visualized in peritoneal carcinomatosis ($p < 0.05$).[33]

A.D Diop et al (2014) analysed that Invasive peritoneal diseases. Although PC the most common aetiology, especially when a primary is found, other conditions may be responsible for peritoneal invasion. A rigorous analysis of CT features taken together with the clinical and biological context usually allowed the main differential diagnoses, which entailed different types of management, to be drawn out. [7]

Alsiagy A. Salama et al (2015) studied MDCT scans of 37 patients with omental lesions after administration of oral and intravenous contrast. Sensitivity, specificity, and diagnostic accuracy of MDCT were calculated. They opined that sensitivity, specificity and diagnostic accuracy of 73%, 92%, 85% and 90%, 95%, 93%, respectively in PTB and PC. This concluded that MDCT is an excellent diagnostic tool for evaluating omental lesions.[34]

Belqees Yawar et al (2015) studied two hundred and three patients with histopathologically proven abdominopelvic malignancies withperitoneal involvement who underwent contrast-enhanced CT abdomen and pelvis. They concluded that peritoneal involvement is common in ovarian and colorectal carcinoma. Mixed pattern of peritoneal pattern was most frequently seen in these patients followed by omental caking and nodular peritoneal deposits. The most common sites of peritoneal involvement were pelvic peritoneum followed by greater omentum.[35]

Dr S. Subhaschandra Singh et al (2016) analysed that peritoneal involvement patterns were helpful in narrowing down the differential diagnosis of diffuse peritoneal diseases. Peritoneal carcinomatosis should be considered if ascites present with irregular peritoneal thickening, nodular omental and peritoneal deposits, omental caking. Tuberculosis can present in dry, wet or fibrotic forms and can strongly mimic peritoneal carcinomatosis; ascites with smooth or irregular peritoneal thickening were common findings. Presence of hepatic or splenic military microabscesses, splenomegaly, inflammatory thickening of the terminal ileum and caecum and caseous lymphadenopathy in appropriate clinical scenario supported abdominal tuberculosis.[36]

Wen-jie Yin et al (2016) performed CT scans in 53 patients with malignant peritoneal mesothelioma (MPM) and 27 patients with tuberculous peritonitis (TBP) confirmed by pathology were retrospectively reviewed. The CT findings were evaluated for the morphologic appearance of ascites, peritoneum, mesenterium and omentum involvement, enlarged lymph nodes, solid abdominal viscera infiltration and metastases, and thoracic changes. Patients in both groups displayed a high proportion of peritoneum and mesenterium thickening. However, TBP showed smooth peritoneal thickening, pleural effusion, and extraperitoneal tuberculosis and MPM showed

irregular thickening, omentum caking, abdominal viscera infiltration and pleural plaques.[37]

Yu-Fei Liang et al (2016) studied two groups in terms of thickness, clinical manifestation, diameter of lymph nodes, ascites, and viscera infiltration. They concluded that smooth and irregular peritoneal thickening, omental cake, mesentery involvement, location of enlarged lymph nodes in cardio-phrenic region were more seen in diffuse malignant peritoneal mesothelioma group whereas peritoneal nodules, nodular type of omentum, location of enlarged lymph nodes in retroperitoneal region, lymph nodes fusion were more commonly detected in PC group.[38]

Sang Woo Shim et al (2017) analysed the computed tomography (CT) features of 18 female peritoneal tuberculosis and 17 peritoneal carcinomatosis from normal-sized ovarian cancer for their differentiation. Omental change, mesenteric change, parietal peritoneal thickening, lymph node enlargement, ascites, ovarian CT attenuation, and ovarian capsular change were analyzed. He concluded that heterogeneous parenchymal hyperattenuation and capsular change of the ovary were more frequently seen in cases of peritoneal carcinomatosis than in cases of female peritoneal tuberculosis ($P = 0.002$, $P < 0.001$, respectively). There were no statistically significant differences in the other CT features.[39]

Farah Naz et al(2018) analysed that out Of the 98 patients identified, 62(63.2%)were found to be cases of disseminated tuberculosis and 36(36.7%) were diagnosed as malignant on histopathology. Computed tomography features were significantly specific to differentiate abdominal tuberculosis from carcinomatosis ($p=0.004$). On computed tomography,4 findings showed statistical significance:- Smooth thickening of the peritoneum ($p<0.001$), abdominal mass ($p=0.03$), lymph node necrosis ($p=0.024$) and high-density ascitic fluid ($p<0.001$). Out of these, smooth thickening of the peritoneum (sensitivity=77%; specificity=86.1%) and high-density ascitic fluid (sensitivity=68.9%;

specificity= 72.2%) were more specific findings. Overall, the sensitivity and specificity of computed tomography was found to be 88.5% and 83.3%, respectively. However, it concluded that no single finding on a computed tomography scan was diagnostic proof of peritoneal tuberculosis, a combination of findings could reliably distinguish between peritoneal tuberculosis and carcinomatosis.[40]

Rochita Venkata Ramanan et al (2019) studied a group of 85 patients, 52 men and 33 women, with peritoneal TB. The control group consisted of 168 consecutive patients, 96 men and 72 women, with PC. The images were analysed for omental thickening and enhancement, peritoneal thickening and nodules, mesenteric thickening and nodules, presence, quantity, loculation and density of ascites, presence of nodes, bowel and other organ involvement as well as a new sign called the CT-OR sign. The CT-OR sign could identify 85% of patients with PTB. It was absent in 96% of patients with PC and was effective in ruling out PC ($p < 0.001$). The sign had a sensitivity of 85%, specificity of 96%, positive predictive value of 92%, negative predictive value of 93% and accuracy of 92%.[41]

Amir H Sohail et al (2021) studied associations of radiological findings in 124 patients (61 males and 63 females) with peritoneal carcinomatosis (n = 55) or tuberculosis (n = 69) using Chi-square test. Sensitivity, specificity, positive and negative predictive value, and total diagnostic accuracy of CT imaging, with histopathology as gold standard, was determined. Subgroup analyses to determine these parameters by age (>40 years and ≤40 years) and gender (male and female) were performed. The most common radiological abnormality in both peritoneal carcinomatosis (90.9%) and peritoneal tuberculosis (89.9%) was omental smudging, followed by presence of extraperitoneal mass (81.8%) in carcinomatosis and presence of micro-nodules in tuberculosis (88.4%). The findings significantly different in both the carcinomatosis and tuberculosis groups were high-density ascites, splenic calcification, splenomegaly, lymph node calcifications,

micro-nodules, and macro-nodules. The diagnostic accuracy of CT in differentiating peritoneal tuberculosis from peritoneal carcinomatosis was 83.8%; sensitivity and specificity for peritoneal tuberculosis were 88.4% and 78.2%, respectively. Subgroup analysis revealed that CT may be a more specific diagnostic tool to predict peritoneal tuberculosis in female patients and in those over 40 years old.[42]

Shyjumon Georgeet al (2022) studied one hundred and thirty-six patients with diffuse peritoneal diseases who had abdominal CT and subsequently underwent omental biopsies and evaluated patients with diffuse peritoneal diseases, to assess the diagnostic value of MDCT in predicting benign or malignant etiology in patients with unknown etiology, by analyzing the various patterns of involvement, particularly tuberculosis (TB) vs malignancy. Peritoneal, mesenteric and omental involvement by disease was evaluated on CT using specific parameters. The presence of lymphadenopathy, ascites, scalloping of organs, involvement of liver and spleen, were also compared between benign and malignant conditions using histopathology as the gold standard. In 136 patients, 72 benign and 64 malignant pathologies were classified as per histopathology. Higher age ($p < 0.001$), increasing omental thickness (mean 25.2 mm, $p = 0.004$), omental caking ($p < 0.001$), > 10 mm mesenteric/peritoneal nodules ($p < 0.03$), visceral scalloping ($p = 0.001$), free ascites ($p = 0.003$), serosal involvement ($p = 0.004$) and bilateral pleural effusion ($p = 0.02$) were associated with malignant etiology. Mesenteric thickening/stranding ($p = 0.02$), mesenteric adenopathy ($p < 0.001$), necrotic nodes ($p = 0.02$), splenomegaly ($p = < 0.001$) and higher attenuation (> 20HU) of ascitic fluid ($p < 0.001$) were associated with benign etiology. The presence of mesenteric thickening or stranding ($p = 0.01$), splenomegaly ($p = 0.02$), higher ascitic fluid attenuation > 20HU ($p = < 0.01$), mesenteric adenopathy ($p < 0.01$), necrotic nodes ($p = 0.03$) favored tuberculosis. CT had diagnostic accuracy (79.3, 86.7%), sensitivity (79.2, 74.6%) and specificity (79.4, 97%) for observers 1 and 2, respectively (Kappa 0.713).[43]

MATERIALS AND METHODS

SOURCE OF DATA –

A prospective study of patients undergoing an multidetector contrast enhanced CT study for peritoneal diseases, at the Department of Radiodiagnosis, Dayanand Medical College & Hospital, Ludhiana during a one year period.

METHOD OF COLLECTION OF DATA

Patients having peritoneal diseases were included in study. Consent was obtained from each patient and relevant detailed history was elicited from all patients. Findings of general physical and systemic examination were recorded in detail . MDCT of patients was performed on Siemens 128 slice CT scan machine after giving intravenous non-ionic iodinated (omnipaque) contrast.

PREPARATION OF PATIENT

The procedure was explained to patient in his/her vernacular language to alleviate fear and anxiety. During the entire period of the procedure patient was in contact with the technician/doctor by a two-way intercom system.

MDCT Protocol for the image acquisition was as follow:

Scan was performed with the patient in supine position in quiet respiration. I.V contrast study using non-ionic water soluble contrast medium was done following plain study.

- Scan duration: 90 seconds with scanning delay time of 30 seconds for arterial phase and 60 seconds for venous phase.
- Scan area of interest: dome of diaphragm to pubic symphysis
- Direction of scan: cranio-caudal
- Collimation: 128*0.6 mm
- Pitch: 0.8
- Reconstructed Slice thickness: 1mm
- Amount of contrast given and injection rate: 1.5ml/kg body weight at the rate of 3 ml/sec

- FOV(field of view): 400-750 mm
- Current : 175mAS
- Voltage: 120 kV

Study design:

This was a longitudinal, prospective study

Inclusion Criterion

- All patients found to have peritoneal diseases on multi-detector contrast enhanced CT.

Exclusion Criterion

- Any contraindications to contrast administration (GFR < 30ml/min)
- Anyone who is unwilling to participate in the study
- Patient who are already on treatment for peritoneal diseases.

MDCT images interpretation:

1) Omental thickening

Omental thickening pattern was assessed for three types

a) Smudgy:- small hazy ground-glass areas
b) Nodular:-discrete scattered enhancing nodules
c) Cake:-diffuse solid enhancement.

2) Peritoneal thickening

Peritoneal thickening was assessed for a regular type where the entire peritoneum was uniformly and smoothly thickened vs an irregular type where it was thickened focally interspersed with areas showing no thickening.

3) Peritoneal nodules

Peritoneal nodules were categorized for size into micro (< 5 mm), macro (> 5 mm) and mixed.

The nodules were further characterised for enhancement into heterogeneous and homogeneous.

4) Mesenteric thickening

The mesentery was considered thickened when it showed presence of increased density.

Mesenteric nodules when present were also classified similar to peritoneal nodules into micro and macro nodules by size.

5) Ascites

Presence or absence of ascites was documented.

When present it was characterised as loculated or free.

Ascites was considered hyperdense (more than 10 HU) and hypodense (less than 10 HU). It was further characterized into mild, moderate and severe. Mild when small amount was detected predominantly in the pelvis without abdominal distension. Moderate when fluid was seen in pelvis as well as abdomen with mild distension and a measurable depth of not more than 3 cm from the abdominal wall. Large when it bulged the flanks and occupied the entire abdomen with significant distension and a measurable depth of more than 3 cm from abdominal wall.

6) Lymph nodes

Presence of lymph nodes in retroperitoneum, periportal/ peripancreatic nodes were also looked for.

7) CT-Omental rim sign

CT-Omental rim sign was looked for and considered positive when a thin or thick rim of uniform thickness, enhancing either moderately or significantly, was clearly identifiable outlining the entire or part of the omentum in venous phase.

The radiological data describing findings of peritoneal diseases were collected and diagnostic findings were correlated with FNAC and histopathological findings and diagnostic effectivity of CECT was calculated for individual parameter and for overall diagnostic performance of CECT for accurately diagnosing etiology of peritoneal diseases.

STATISTICAL ANALYSIS

Data were described in terms of range; mean ±standard deviation (± SD), frequencies (number of cases) and relative frequencies (percentages) as appropriate. For comparing categorical data, Chi square ($\chi 2$) test was performed and fisher exact test was used when the expected frequency is less than 5. A probability value (p value) less than 0.05 was considered statistically significant. All statistical calculations were done using (Statistical Package for the Social Science)SPSS 21version (SPSS Inc., Chicago, IL, USA)statistical program for Microsoft Windows.

OBSERVATIONS AND RESULTS

DEMOGRAPHIC DATA

35 patients were evaluated in this study between the period of March 2021 to February 2022. The age range of patients was from 16-77 years with mean age of 46.66 ± 16.97 in (Table 1, Figure 1), including 24 females and 11 males as shown in (Table 2, Figure 2).

Table 1: Age distribution of patients

Age group	No. of cases	Percentage
< 30	6	17.1%
31-40	8	22.9%
41-50	8	22.9%
> 50	13	37.1%
Total	35	100.0%

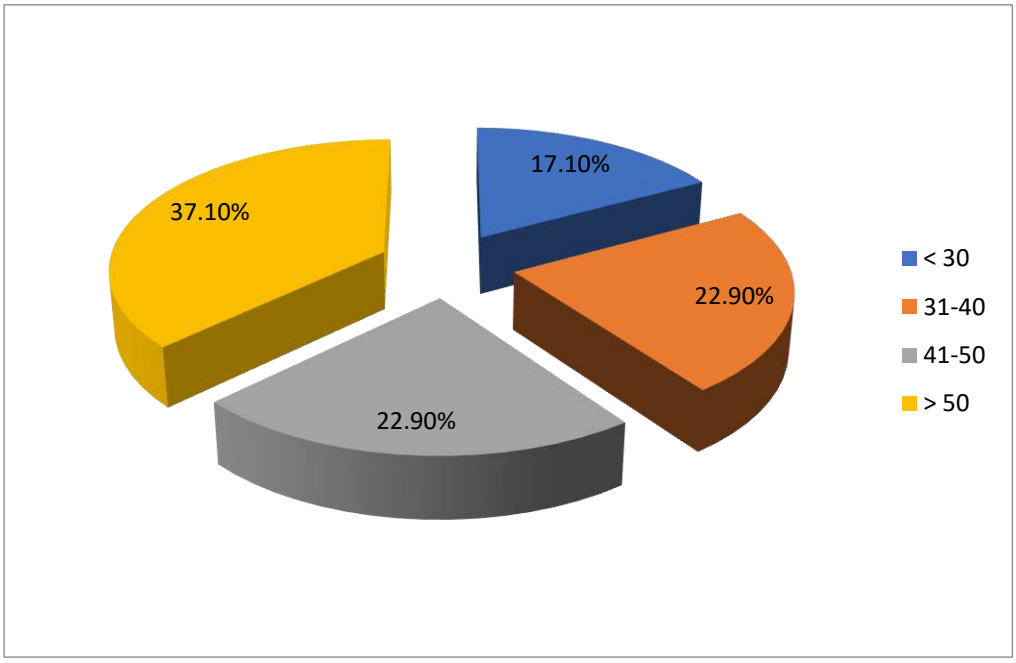

Figure 1: Age group distribution (years) with percentage of cases

Table 2: Gender distribution of patients

Sex	No. of cases	Percentage
female	24	68.6%
male	11	31.4%
Total	35	100.0%

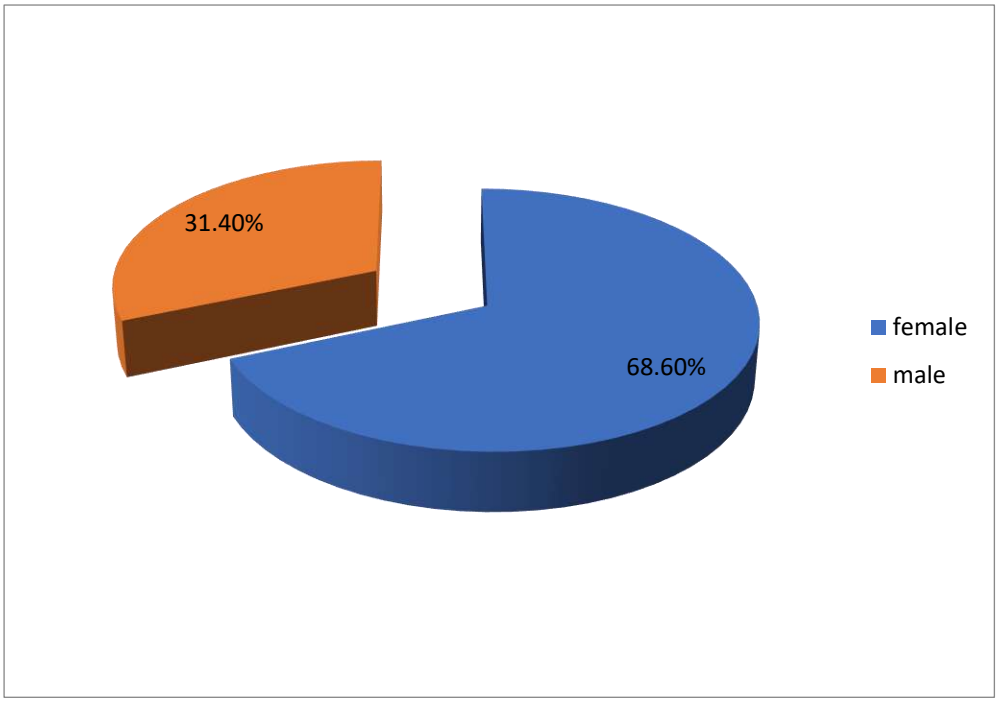

Figure 2: Gender distribution of patients

Peritoneal thickening

Most PTB and PC patients showed peritoneal thickening with only 1% of PTB showing no peritoneal thickening. Of the PC who had peritoneal thickening majority (90.5%) were Irregular/nodular with only 9.5% being diffuse-smooth thickening, making this an important differentiator ($p < 0.001$).

85.7% of PTB patients in our study showed diffuse and 7.1% shows irregular thickening ($p < 0.001$). (Table 2, Figure 2).

Table 3: Patterns of peritoneal thickening

	Carcinoma		Tuberculosis	
Peritoneal thickening	No. of cases	Percentage	No. of cases	Percentage
Absent	0	0.0%	1	7.1%
Diffuse-smooth	2	9.5%	12	85.7%
Irregular/Nodular	19	90.5%	1	7.1%

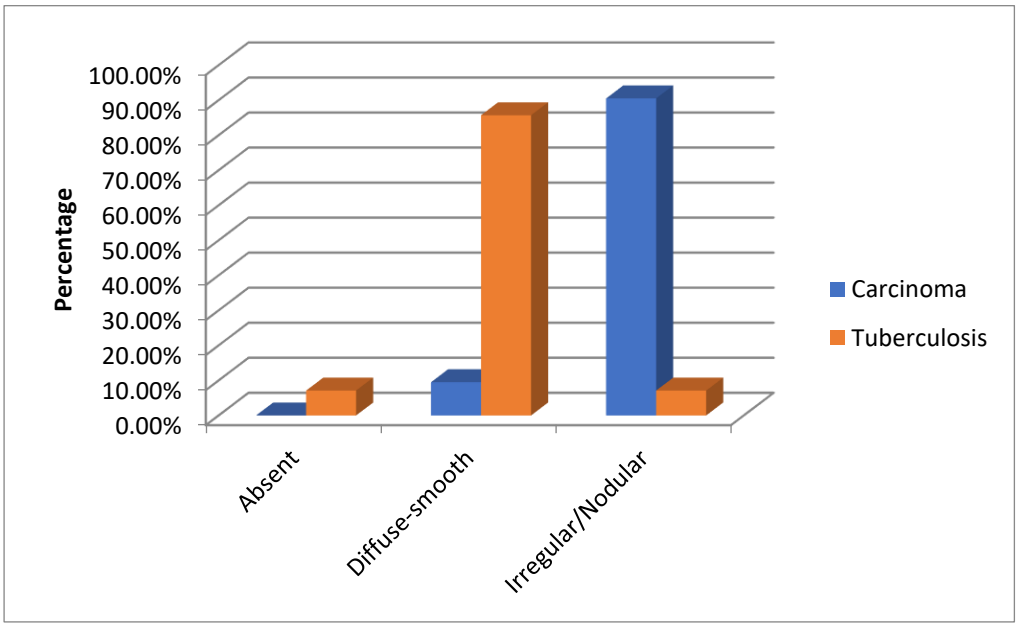

Figure 3: Patterns of peritoneal thickening

Peritoneal nodules

Majority of PTB had micronodules with some having mixed, micro or macro types. Micro peritoneal nodules were present in 71.4% of the PTB and 28.6% in PC patients helps in differentiating the two with p value of 0.016. PC had 28.6% micro, 4.8% macro and 66.7% mixed. Mixed peritoneal nodules were present in 66.7% OF PC (p<0.001). (Table 4, Figure 4).

Table 4: Types of peritoneal nodules

	Carcinoma		Tuberculosis	
Peritoneal nodules	No. of cases	Percentage	No. of cases	Percentage
Micro-nodules(<5mm)	6	28.6%	10	71.4%
Macro-nodules(>5mm)	1	4.8%	3	21.4%
Mixed	14	66.7%	0	0.0%

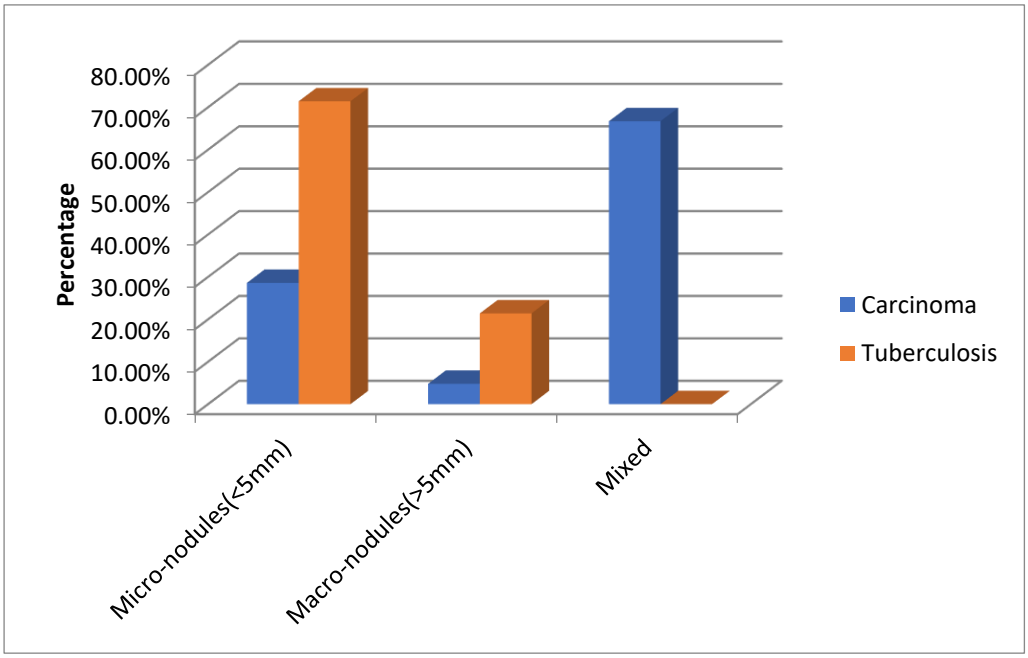

Figure 4: Types of peritoneal nodules

Peritoneal nodular enhancement

The peritoneal nodule enhancement pattern of hetero or homogeneous helps in differentiate between PTB and PC. In PC majority (61.9%) had heterogenous enhancement with only 38.1% showed homogenous enhancement making this an important differentiator ($p < 0.001$). 92.9% of PTB patients in our study showed homogenous enhancement ($p < 0.001$). (Table 5, Figure 5).

Table 5: Pattern of peritoneal nodular enhancement

	Carcinoma		Tuberculosis	
Peritoneal nodular enhancement	No. of cases	Percentage	No. of cases	Percentage
Homogenous	8	38.1%	13	92.9%
Heterogenous	13	61.9%	0	0.0%

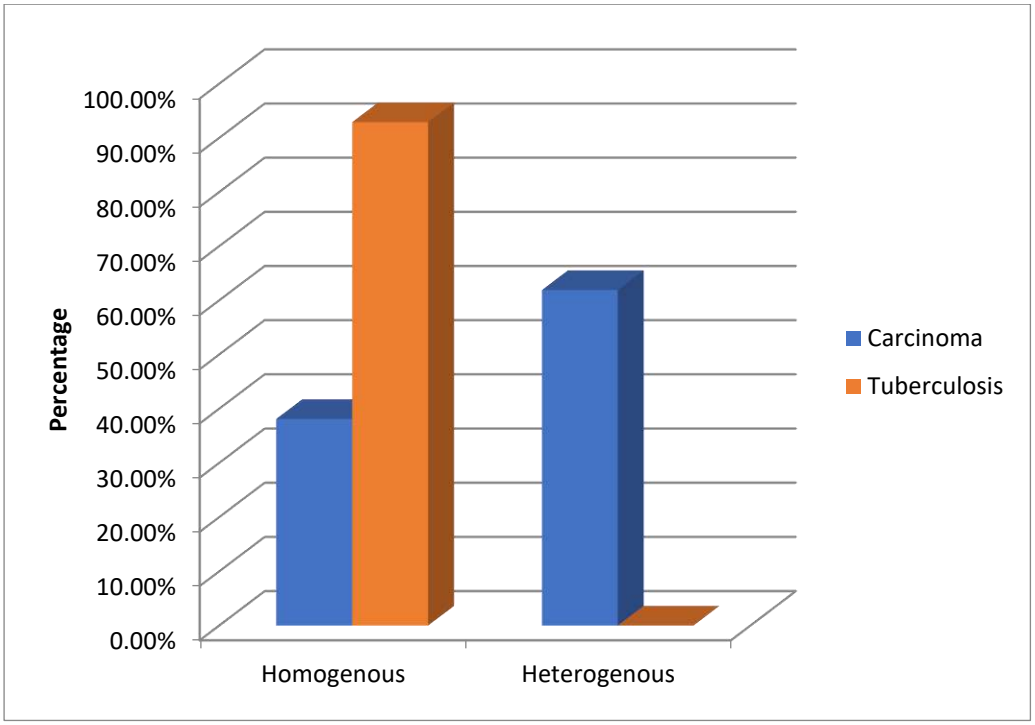

Figure 5: Pattern of peritoneal nodular enhancement

Omental thickening

All patients in our study had omental thickening. PTB and PC can be differentiated based on smudgy pattern of omental thickening as 64.3% of PTB had a smudgy pattern of omental thickening as compared to 19 % of PC [p - 0.012]. Nodular pattern was also more common with PC (61.9%) vs PTB (28.6%) with (p-0.086). Cake like enhancement was seen in 19% of PC and in 7.1% of PTB (p-0.324). (Table 6, Figure 6).

Table 6: Pattern of omental thickening

	Carcinoma		Tuberculosis	
Omental Thickening	No. of cases	Percentage	No. of cases	Percentage
Smudgy	4	19.0%	9	64.3%
Cake-like	4	19.0%	1	7.1%
Nodular	13	61.9%	4	28.6%

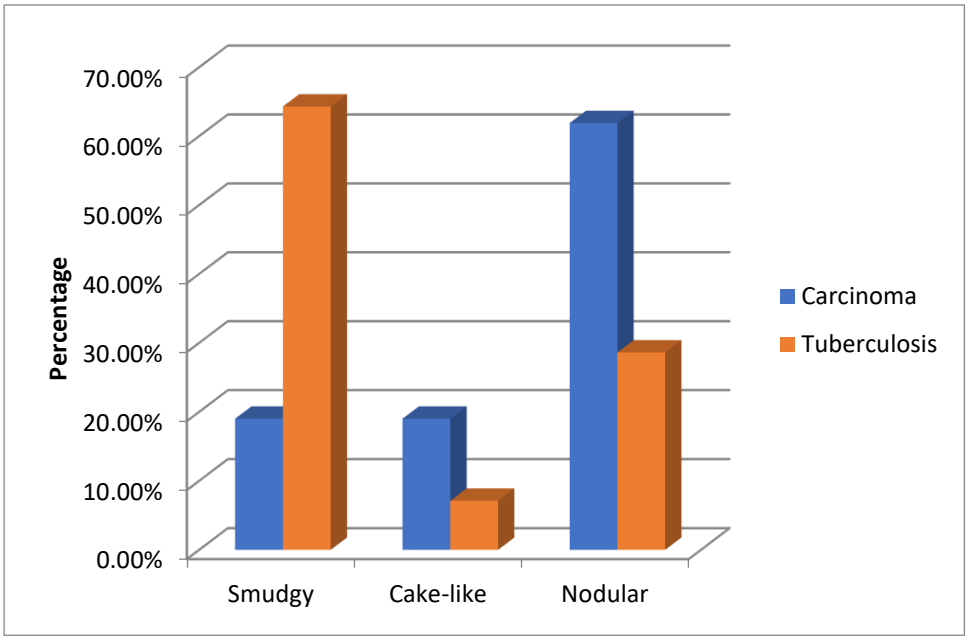

Figure 6: Pattern of omental thickening

Mesenteric thickening

Mesenteric thickening was present in majority of both PTB (85.7%) and PC (71.4%) with p value of 0.324. (Table 7, Figure 7).

Table 7: CT finding of mesenteric thickening

	Carcinoma		Tuberculosis	
Mesenteric Thickening	No. of cases	Percentage	No. of cases	Percentage
Absent	6	28.6%	2	14.3%
Present	15	71.4%	12	85.7%

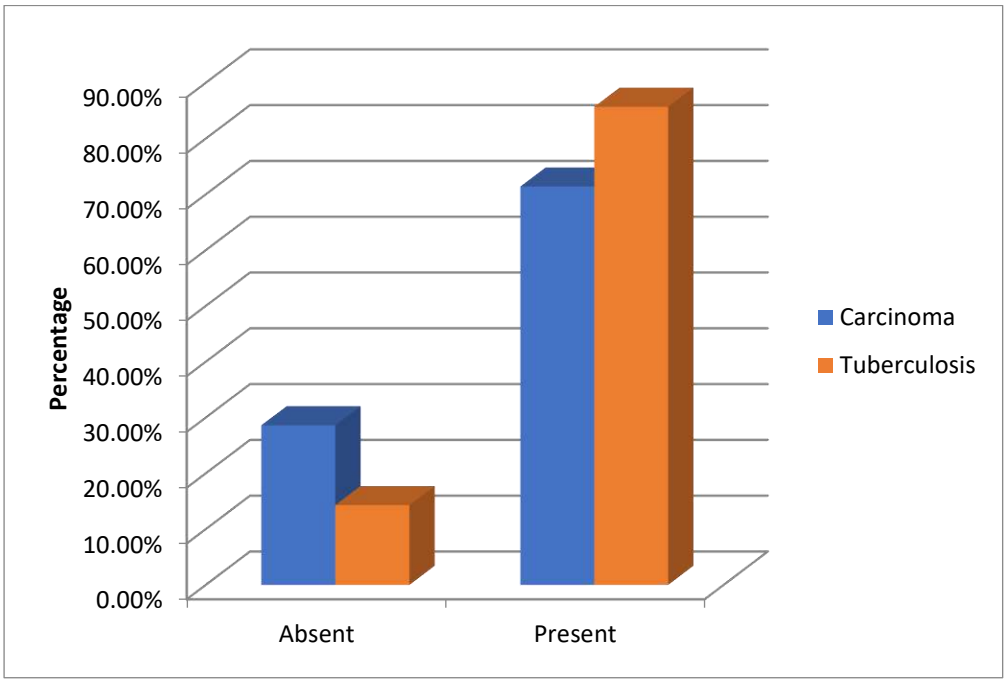

Figure 7: CT finding of mesenteric thickening

Mesenteric nodule

Majority of nodules in both disease was of the mixed type 47.6% in PC and 35.7% in PTB with p value of 0.486. (Table 8, Figure 8).

Table 8: Types of mesenteric nodules

	Carcinoma		Tuberculosis	
Mesenteric nodules	No. of cases	Percentage	No. of cases	Percentage
Absent	3	14.3%	1	7.1%
Micro	5	23.8%	3	21.4%
Macro	3	14.3%	5	35.7%
Mixed	10	47.6%	5	35.7%

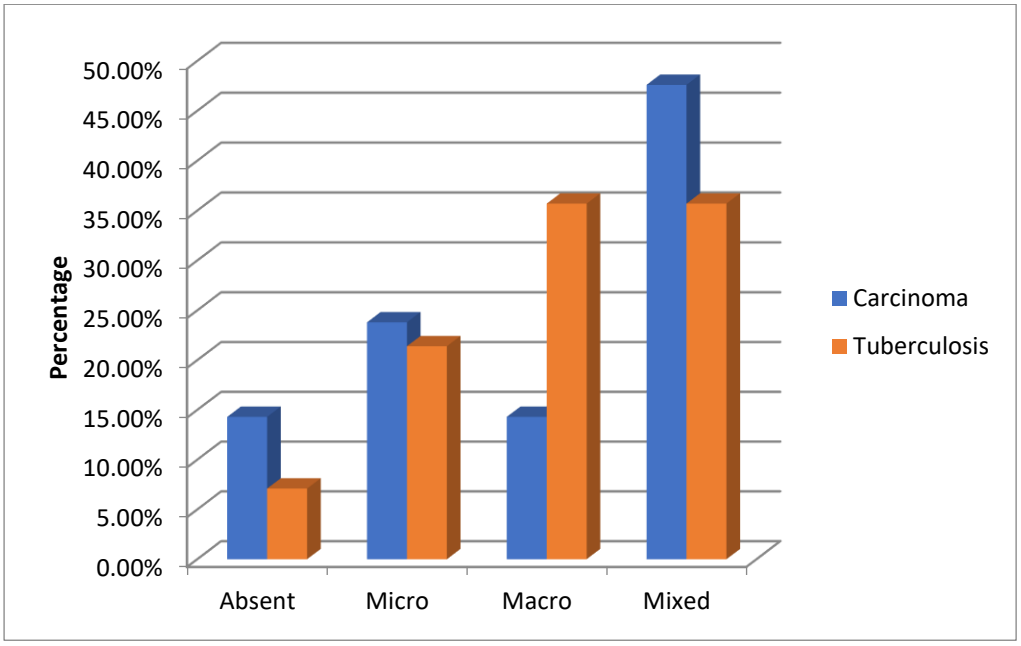

Figure 8: Types of mesenteric nodules

Ascites

66.7% of PC and 71.4% of PTB had free ascites whereas 33.3% of PC and 28.6 % of PTB had loculated ascites (p = 0.766). Most PTB (64.3%) and PC (61.9%) patients had hyperdense ascites. However, PTB (35.7%) patients as compared to PC (38.1%) had hypodense (< 10HU) ascites (p = 0.886). (Table 9a-9c, Figure 9a-9c).

Table 9a: Types and presence of ascites

	Carcinoma		Tuberculosis	
Ascites presence and types	No. of cases	Percentage	No. of cases	Percentage
Free	14	66.7%	10	71.4%
Loculated	7	33.3%	4	28.6%

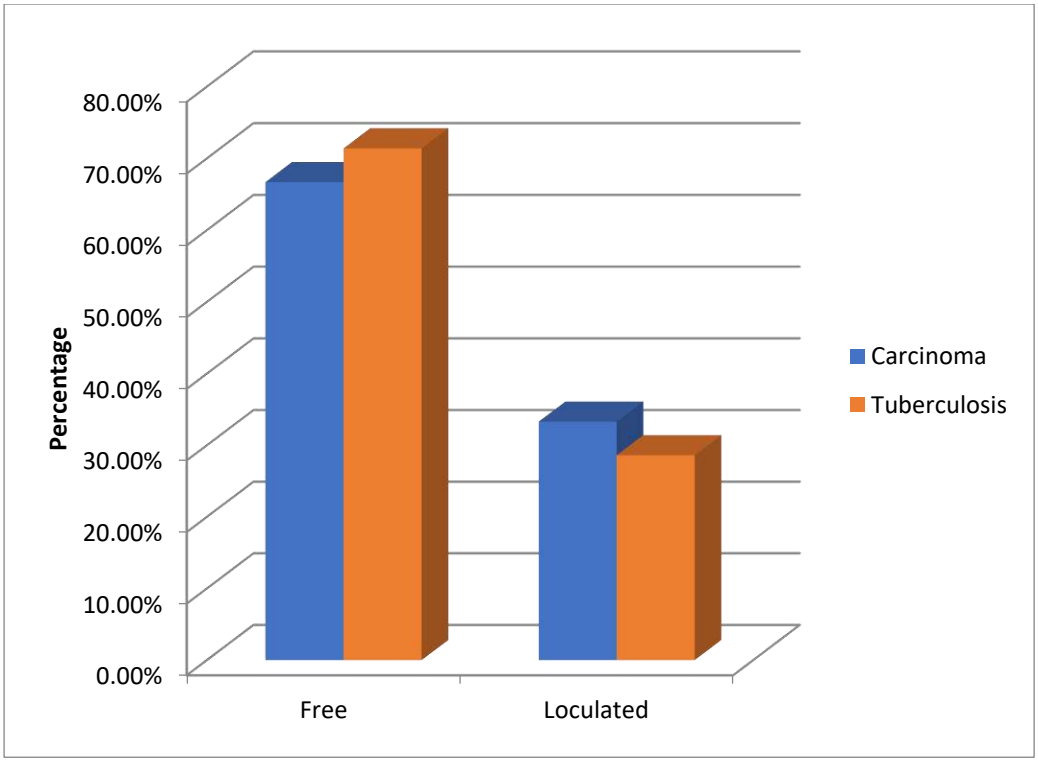

Figure 9a: Types and presence of ascites

Table 9b: Quantity of ascites

	Carcinoma		Tuberculosis	
Ascites quantity	No. of cases	Percentage	No. of cases	Percentage
Mild	5	23.8%	6	42.9%
Moderate	6	28.6%	3	21.4%
Large	10	47.6%	5	35.7%

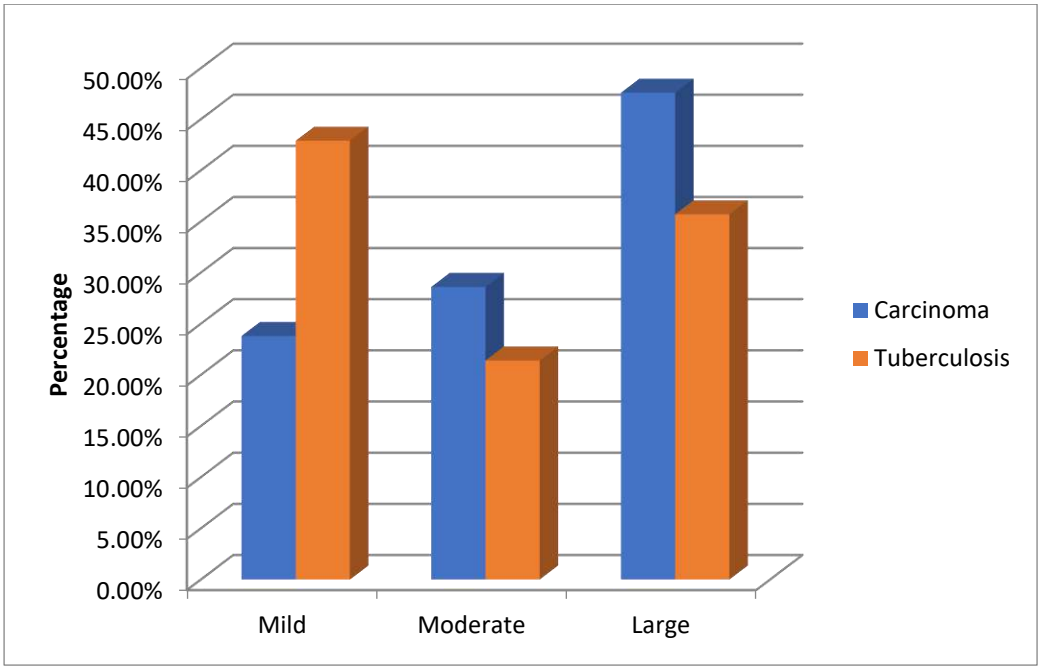

Figure 9b: Quantity of ascites

Table 9c: Density of ascites

	Carcinoma		Tuberculosis	
Ascites density	No. of cases	Percentage	No. of cases	Percentage
Hyperdense (>10HU)	13	61.9%	9	64.3%
Hypodense (<10HU)	8	38.1%	5	35.7%

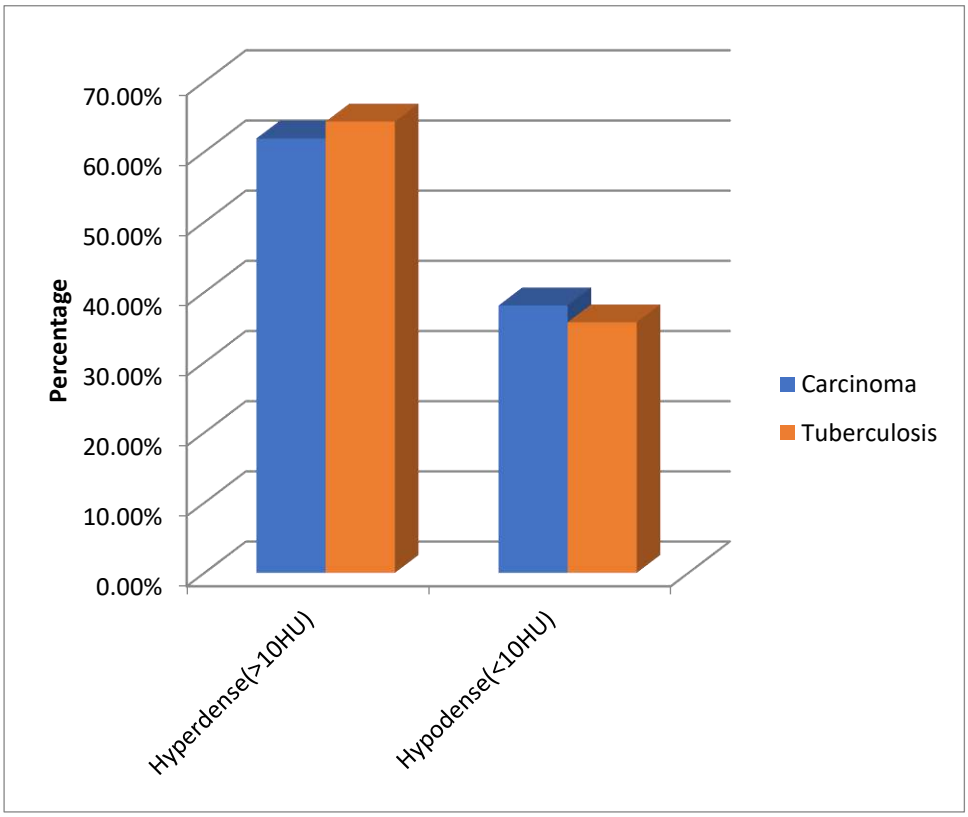

Figure 9c: Density of ascites

Omental rim sign

Out of 35 cases,7 cases had CT-Omental rim sign positive in which 5 cases were of TB and 2 cases were of peritoneal carcinomatosis with insignificant p value of 0.057. (Table 10, Figure 10).

Table 10: CT-omental rim sign

	Carcinoma		Tuberculosis	
Omental Rim Sign	No. of cases	Percentage	No. of cases	Percentage
Absent	19	90.5%	9	64.3%
Present	2	9.5%	5	35.7%

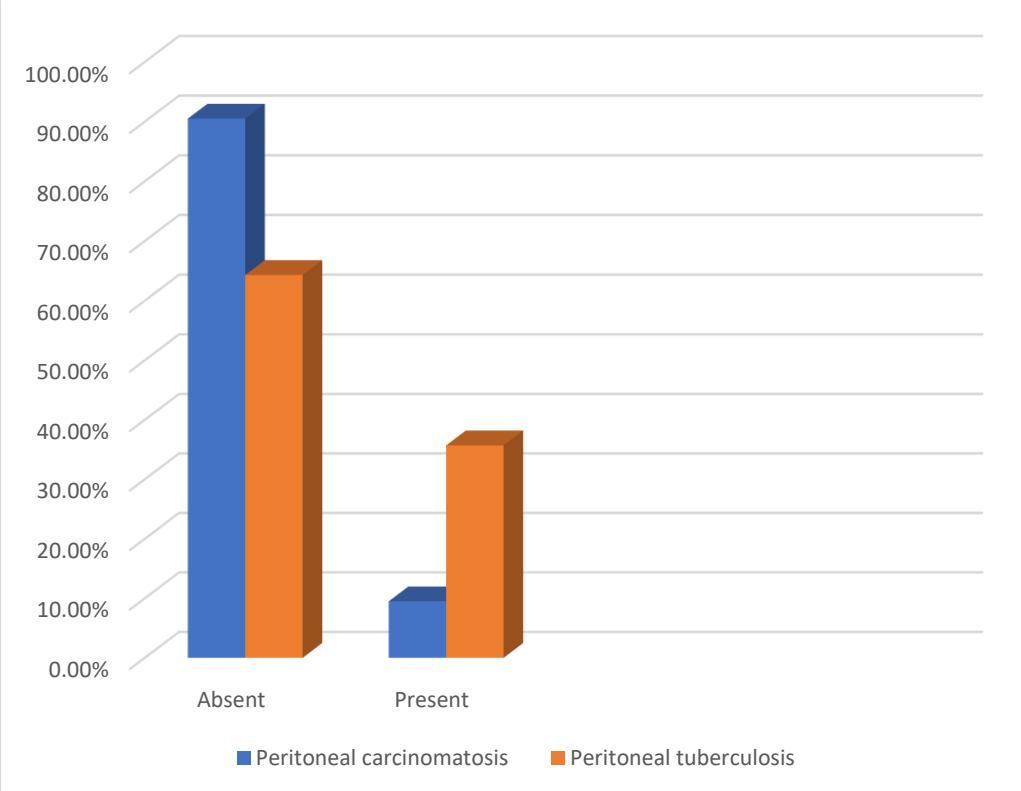

Figure 10: CT-omental rim sign

Retroperitoneal and mesenteric lymph nodes

Of our PTB patients 7.1% had retroperitoneal necrotic nodes and 21.4% homogenous retroperitoneal nodes,28.6% mesenteric necrotic nodes and 64.3% shows homogenous mesenteric nodes. (Table 11a-b, Figure 11a-b).

Table 11a: Types of retroperitoneal nodes

	Carcinoma		Tuberculosis	
Retroperitoneal nodes	No. of cases	Percentage	No. of cases	Percentage
Absent	13	61.9%	10	71.4%
Necrosis	1	4.8%	1	7.1%
Homogenous	7	33.3%	3	21.4%

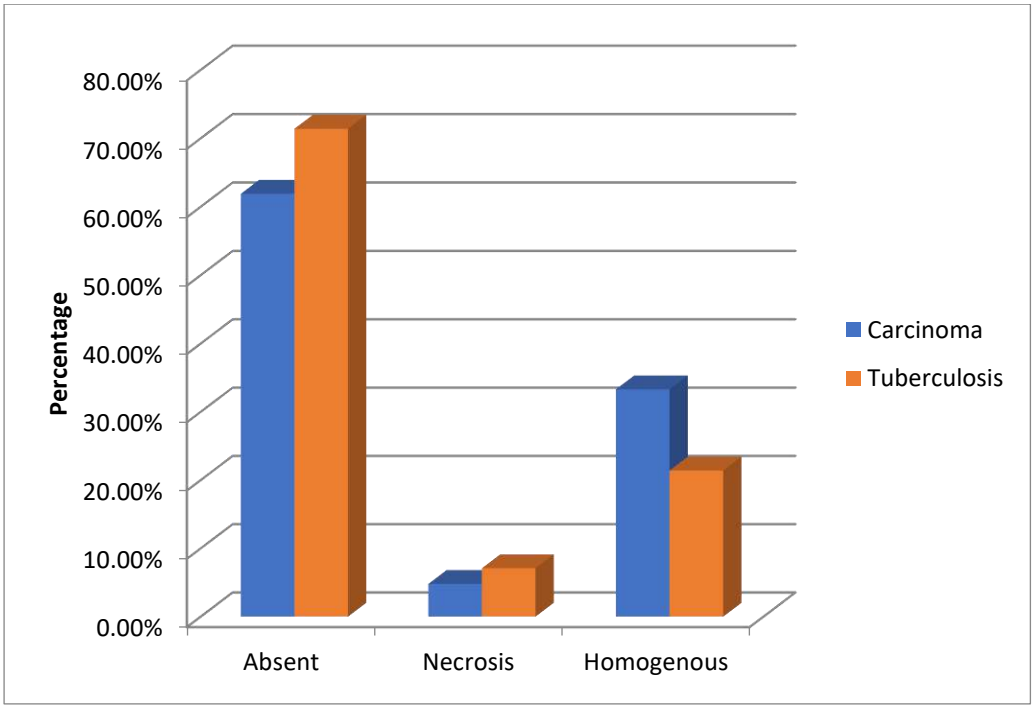

Figure 11a: Types of retroperitoneal nodes

Table 11b: Types of mesenteric nodes

Mesenteric nodes	No. of cases	Percentage	No. of cases	Percentage
Absent	3	14.3%	1	7.1%
Necrosis	2	9.5%	4	28.6%
Homogenous	16	76.2%	9	64.3%

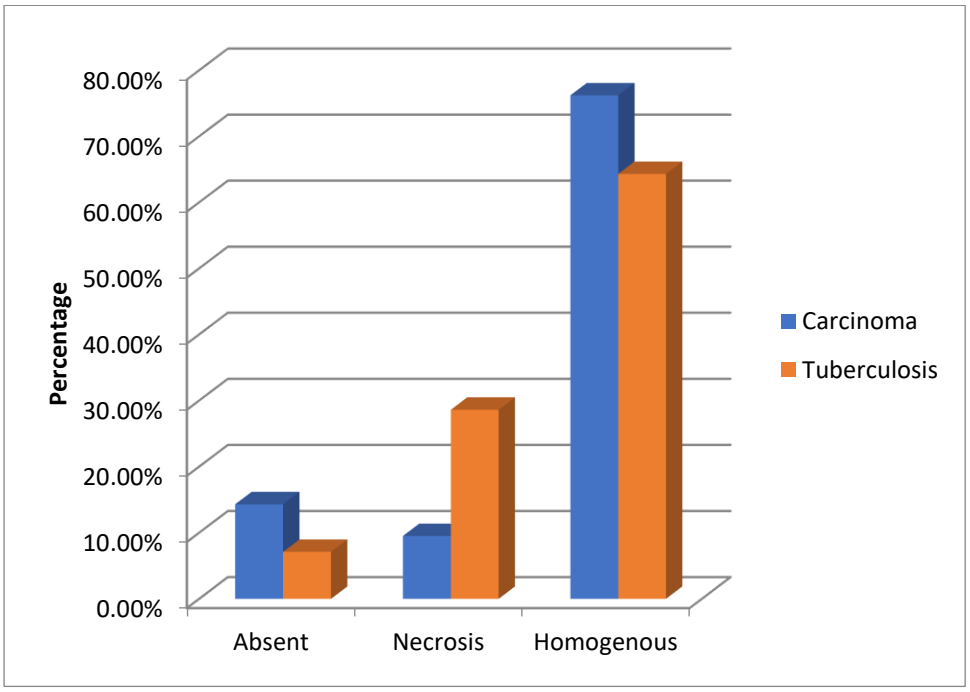

Figure 11b: Types of mesenteric nodes

CBNAAT

Out of 35 patients, only 16 patients had undergone CBNAAT testing and only 3 patients were positive. (Table 12, Figure 12).

Table 12: Lab parameter showing CBNAAT

	Carcinoma		Tuberculosis	
CBNAAT	No. of cases	Percentage	No. of cases	Percentage
Negative	8	38.1%	5	35.7%
Positive	0	0.0%	3	21.4%

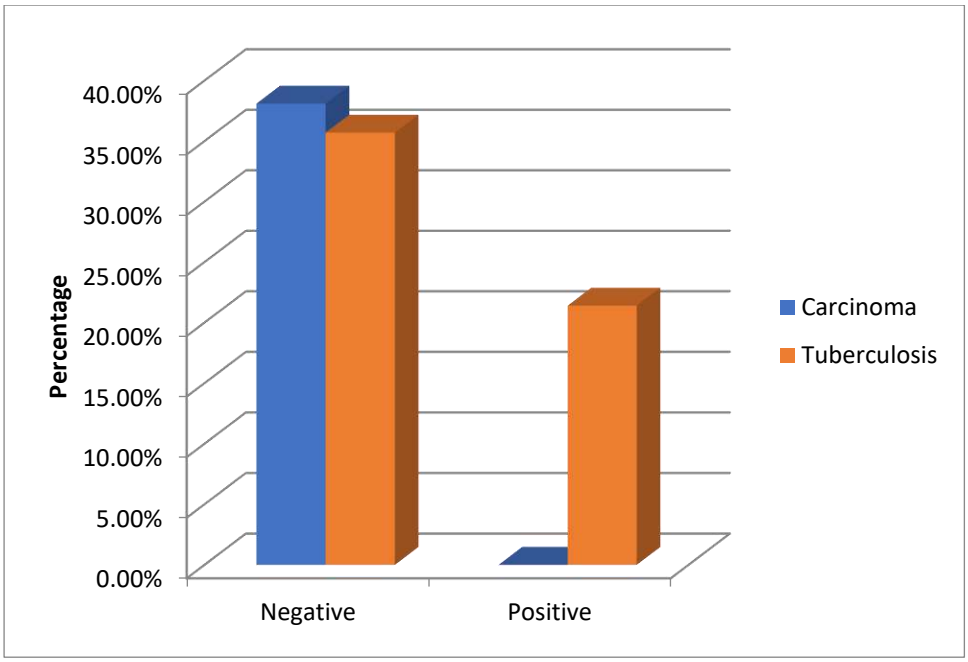

Figure 12: Lab parameter showing CBNAAT

DISCUSSION

Early diagnosis of peritoneal diseases and differentiation between PTB and PC is of paramount importance in order to prevent morbidity. In this era of cytoreductive surgery and hyperthermic intraperitoneal chemotherapy with good outcomes for PC, early diagnosis and initiation of therapy cannot be over emphasised [44]. However, differentiating PTB from PC has remained a challenge clinically as well as on imaging and laboratory tests.

Identification of a primary malignant tumour in the abdomen helps to rule out PTB. However, PC from ovarian malignancies where ovaries are normal sized [45] or in cases where the primary cancer in any other organ is too small to be detected or unknown as well as cases of primary papillary serous carcinoma of peritoneum which has been reported to be on the rise, remain clinical scenarios where arriving at a diagnosis becomes difficult.[46]

Peritonitis is the most common clinical manifestation of abdominal TB, affecting 77% of patients in one recent study from the Indian subcontinent.[47] The route of infection may be haematogenous or direct spread from a ruptured node, infected bowel or fallopian tube.[48] On imaging PTB is said to have three different types. However considerable overlap exists between these patterns. The wet type presents with free or loculated ascites. The dry or plastic type presents with caseous nodules, fibrous peritoneal reaction, and dense adhesions. The fibrotic fixed type presents with an omental mass, matting of bowel and mesentery and occasionally loculated ascites [49]. In our study, majority of PTB were the wet type.

Though CT is currently the most useful tool to image peritoneal diseases, findings in PTB may be nonspecific. Disseminated peritoneal malignancy, nontuberculous peritonitis, and mesothelioma remain close differentials.[48] The various direct characteristics used to differentiate PTB from PC on imaging are ascites, peritoneal, omental and mesenteric abnormalities. Presence of lymph nodes and their

enhancement pattern as well as other abdominal organ involvement are used as indirect characteristics. However, larger peritoneal deposits which may cause solid organ scalloping suggest PC.[50]

Peritoneal changes have thus far been the strongest differentiator of PTB from PC. Our study analysed that smooth and uniform peritoneal thickening was more frequently seen in peritoneal tuberculosis(85.7%) than peritoneal carcinomatosis (9.5%) patients ($p < 0.001$) and irregular/nodular peritoneal thickening were more frequently seen in peritoneal carcinomatosis(90.5%) patients than of peritoneal tuberculosis (7.1%) patients ($p < 0.001$).

Rodriguez et al.[30] found that smooth diffuse peritoneal thickening in PTB and irregular peritoneal thickening in PC with p value of <0.001. Charoensak et al.[33] analysed that irregular peritoneal thickening more commonly seen in PC and diffuse and smooth peritoneal thickening in PTB with p value of <0.001. Naz et al.[40] found that smooth peritoneal thickening more in PTB as compared to PC with p value of <0.001.Ramanan et al.(41) analysed that smooth diffuse peritoneal thickening more commonly seen in PTB and irregular peritoneal thickening more in PC with p value of <0.001. Hence, pattern of peritoneal thickening can be considered an important sign to differentiate PC from PTB.

Micronodules in PTB and mixed nodules in PC helps in differentiating between the two with p value of 0.018 and p value <0.001 respectively. Our study showed that in PTB 71.4% of patients had micronodules (p value-0.018), 21.4% of patients had macro-nodules (p value 0.129). In our study, large peritoneal nodules were not seen in PTB. PC had 28.6% micro, 4.8% macro and 66.7% mixed (p<0.001). Ha et al.[29] found that macro-nodules were commonly seen in PTB with p value <0.01 while Charoensak et al.(33) and Ramanan et al.[41] as well as or found this finding to be statistically insignificant. This difference could be due to difference in sample size and more studies are required to validate its significance.

In PC majority (61.9%) had heterogenous enhancement of nodules with only 38.1% showed homogenous enhancement making this an important differentiator (p < 0.001). 92.9% of PTB patients in our study showed homogenous enhancement (p <0.001). Ramanan et al.[41] found the enhancement pattern of nodules to be statistically insignificant. This difference could be due to difference in sample size and more studies are required to validate its significance.

We found that 64.3% of PTB had a smudgy pattern of omental thickening as compared to 19 % of PC [p - 0.012]. PTB and PC can be differentiated based on smudgy pattern of omental thickening as. Charoensak et al.[33] found that omental smudginess more commonly seen in PTB with p value of <0.001. H.K. Ha et al.[29] analysed that PTB had omental smudginess pattern with p value of <0.05. Ramanan et al.[41] found a smudgy pattern of omental enhancement to be a significant predictor of PTB (p < 0.02) [9,11,17].

Omental nodular pattern was also more common with PC (61.9%) vs PTB (28.6%) with (p-0.086). Charoensak et al.[33] found that omental nodularity was more commonly seen in PC with p value of <0.001 while Ha et al.[29] as well as our study found this to be statistically insignificant.

Omental caking was seen in 19% of PC and in 7.1% of PTB (p-0.324). Charoensak et al.[33] and Ramanan et al.[41] found omental caking to be more commonly seen in PC while Rodriguez et al.[30], Ha et al.[29] as well as our study found this to be statistically insignificant.

Out of 35 cases, we found CT-OR sign in 7 cases in which 5 cases were of PTB and 2 cases were of peritoneal carcinomatosis with insignificant p value of 0.057. Ha et al.[29], mentioned an omental line which they described as a fibrous wall covering the omentum in 50% of their PTB patients vs only 5% of their PC patients (p < 0.01). This line is comparable to our CT-omental rim sign. However, our sign differs from it in the characteristics that our omental rim can be thick as well as thin. Ramanan et al.[41] found CT omental rim to be statistically

significant with p value of 0.001 but our study found this to be statistically insignificant likely due to small sample size.

Mesenteric thickening was present in majority of both PTB (85.7%) and PC (71.4%) with p value of 0.324. Ha et al.[29] found mesenteric thickening to be statistically significant with p value <0.05 while Charoensak et al.[33], Ramanan et al.[41] as well as our study found this to be statistically insignificant.

Majority of mesenteric nodules in both disease was of the mixed type 47.6% in PC and 35.7% in PTB with p value of 0.486. Mesenteric macro-nodules more common in PTB according to Ha et al.[29] with p value of <0.01.

The common occurrence of mesenteric micro- or macro-nodules in tuberculous peritonitis appears to be because tuberculous peritonitis develops from the rupture of mesenteric lymph nodes seeded by the hematogenous or lymphatic routes from primary lesion sites [16] or direct spread from serosa by continuity from adjacent glands or structures. Therefore, the mesenteric nodules seen on CT represent tubercles either in lymph nodes or on mesenteric surfaces.

66.7% of PC and 71.4% of PTB had free ascites whereas 33.3% of PC and 28.6 % of PTB had loculated ascites (p = 0.766) which was statistically insignificant. Charoensak et al.(33)found that loculated ascites was more common in PTB with p value of <0.05 while Rodriguez et al.[30], Ha et al.[29], Ramanan et al.[41] found this to be statistically insignificant .

Most PTB (64.3%) and PC (61.9%) patients had hyperdense ascites. However, PTB (35.7%) patients as compared to PC (38.1%) had hypodense (< 10HU) ascites (p = 0.886). Ramanan et al.[41] and Naz et al.[40] found ascites to be hyperdense in PTB with p value of <0.02 and <0.001 respectively while Charoensak et al.[33] and Ha et al.[29] as well as our study found this to be statistically insignificant.

Our study found 7.1% of necrotic retroperitoneal and 28.6% of necrotic mesenteric nodes in PTB and homogenous retroperitoneal nodes in 21.4% and homogenous mesenteric nodes in 64.3% of PTB while 4.8% of necrotic retroperitoneal and 9.5% of necrotic mesenteric nodes in PC and homogenous retroperitoneal nodes in 33.3% and homogenous mesenteric nodes in 76.2% of PC patients. Ha et al.[29] found para-aortic nodes more in PTB and Charoensak et al.[33] found peri-pancreatic as well as subcentimetric sized nodes more in PTB. Neither ours nor any other study could confirm this. Presence of necrotic nodes has been considered a useful indirect sign to rule out PC. However, up to 62% of metastatic adenocarcinoma nodes may also show necrosis.[41]

LIMITATIONS

Although data from our current study is encouraging but the study included a small number of patients, especially for those with CT-omental rim sign. We didn't include terminal ileal thickening, CA-125 levels and patients with peritoneal carcinomatosis on treatment. As a result a large sample size, terminal ileal thickening, CA-125 level correlation would helps in further establish the differences between peritoneal tuberculosis and peritoneal carcinomatosis.

SUMMARY & CONCLUSION

Differentiation of peritoneal carcinomatosis (PC) and peritoneal tuberculosis (PTB) has been challenging thus far on CT with many overlapping findings. CT findings like omental smudginess, smooth homogenous peritoneal thickening, peritoneal micronodules and homogenous peritoneal nodular enhancement can be useful in favouring the diagnosis of peritoneal tuberculosis over peritoneal carcinomatosis. Although, CT-omental rim sign is seen in most of the cases of peritoneal tuberculosis but larger studies assessing this sign may validate it to be an important marker of PTB on CT.

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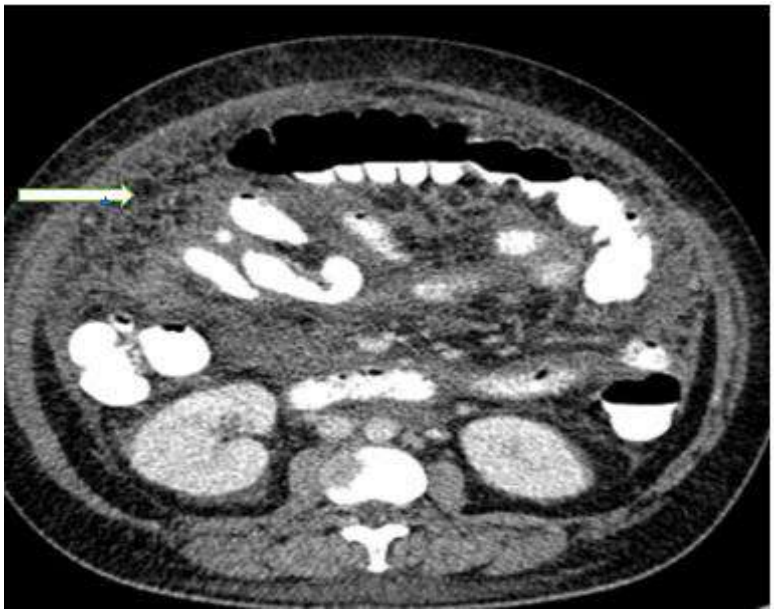
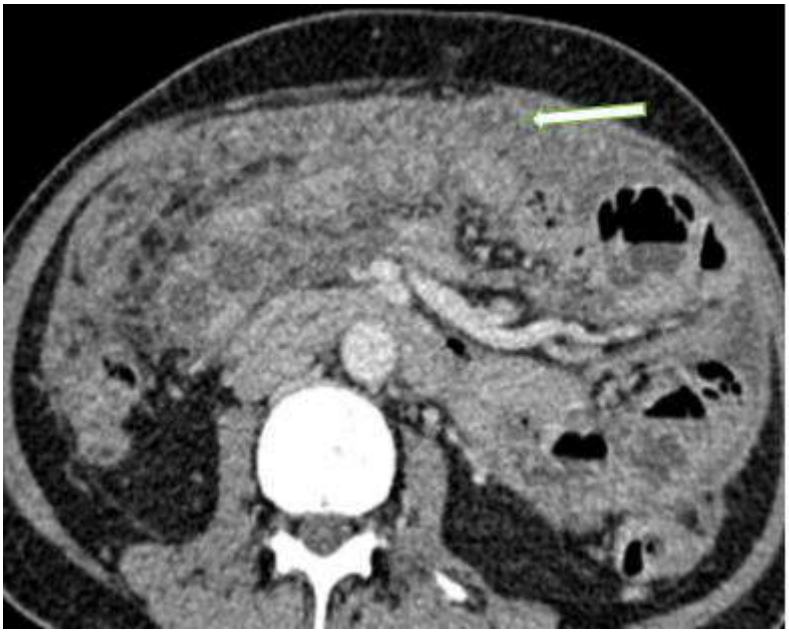
CASES

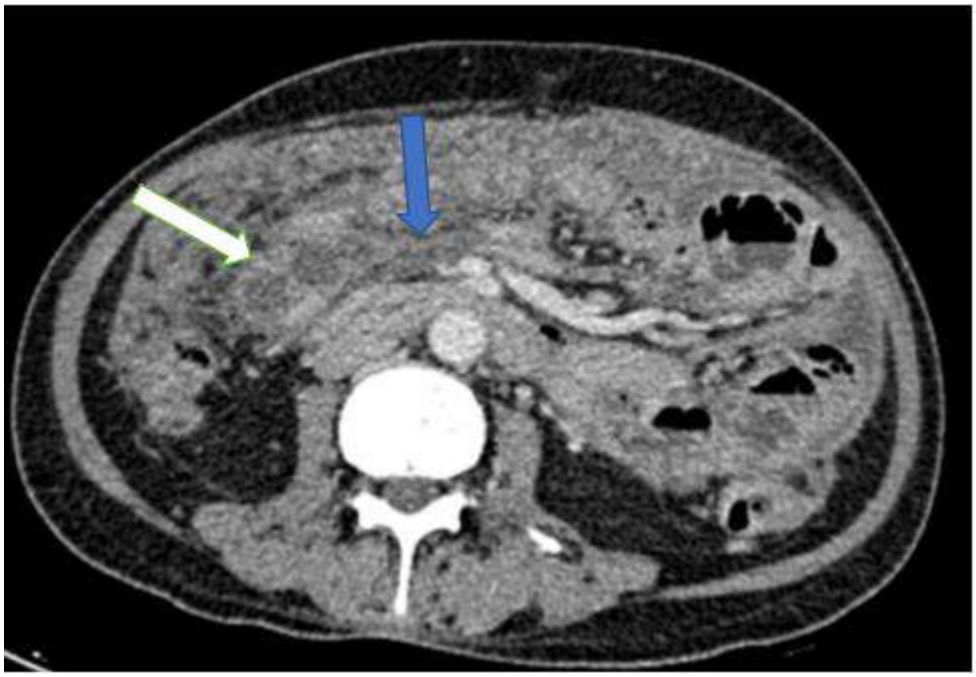


Picture 1: Contrast enhanced CT axial image shows omental smudginess in patient of peritoneal tuberculosis



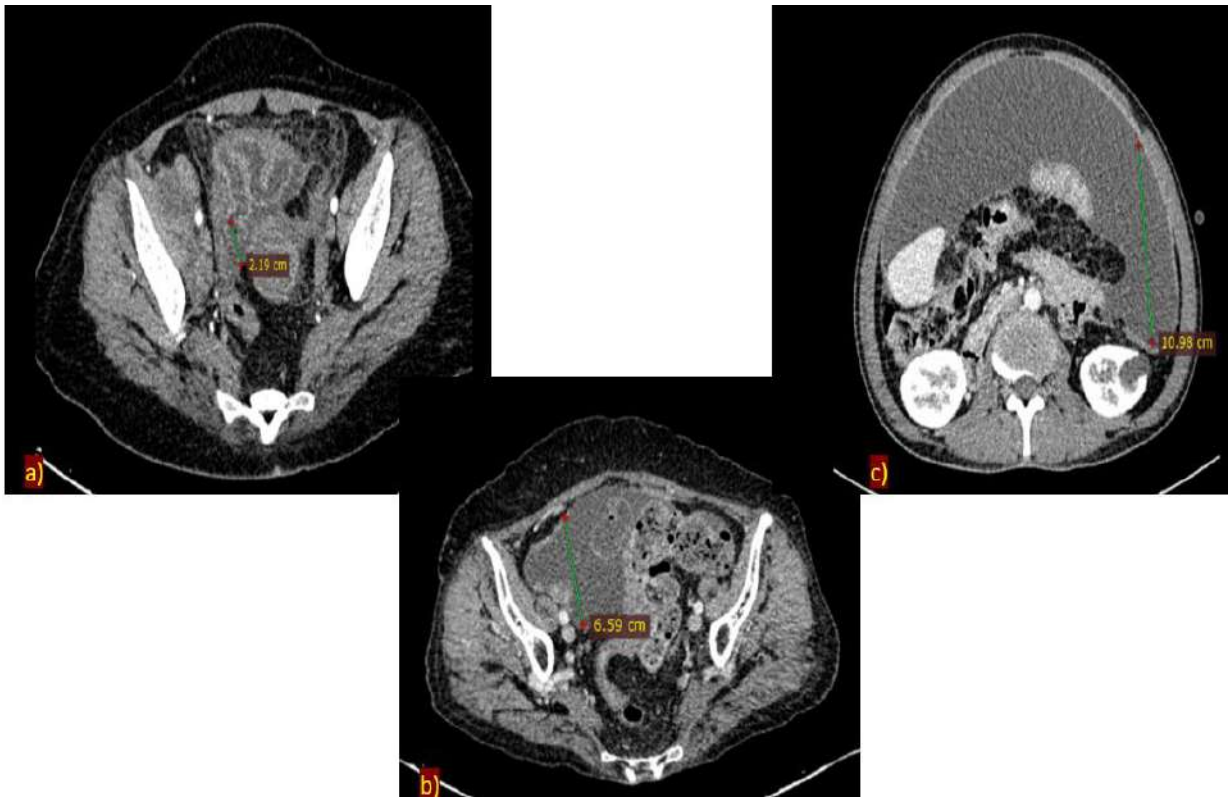
Picture 2: Contrast enhanced CT image shows omental caking in peritoneal carcinomatosis

Picture 3: **Contrast enhanced CT axial image shows omental nodularity in peritoneal carcinomatosis.**

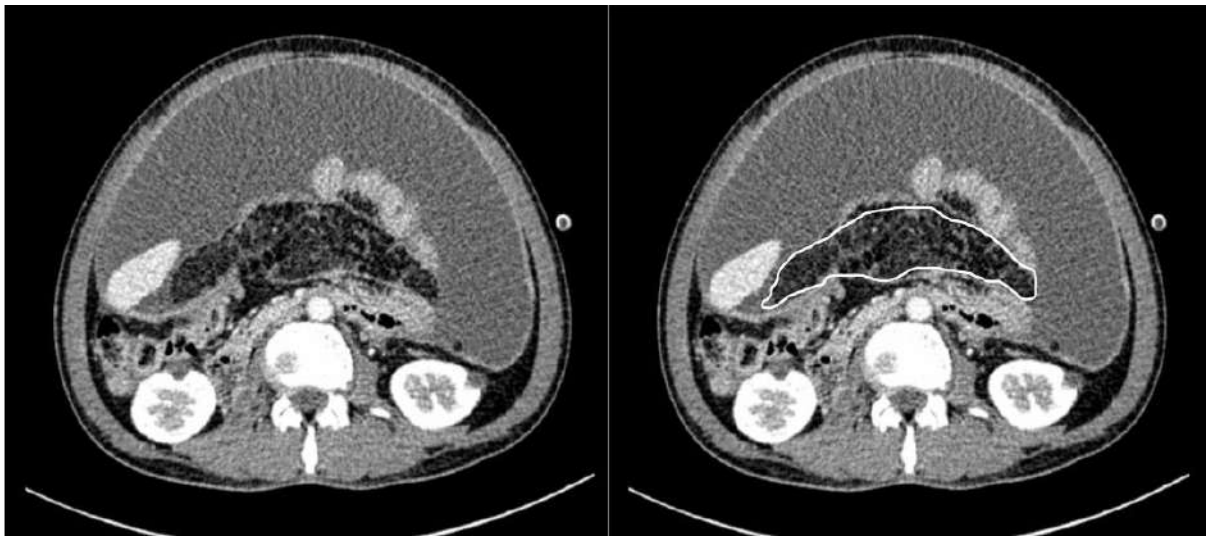


Picture 4: CECT axial image shows mesenteric thickening (blue arrow) and mesenteric necrotic lymphadenopathy (white arrow).

Picture 5: Contrast enhanced CT axial images showing smooth uniform(white arrow) and irregular nodular(blue arrow) peritoneal thickening in biopsy proven cases of peritoneal tuberculosis and peritoneal carcinomatosis respectively.



Picture 6(a-c) : CECT axial images showing ascites a) Mild [Only in pelvis with maximum depth <3cm], b) Moderate [In pelvis and abdomen with maximum depth of 3cm] and c) Large [Bulging flanks with measurable depth >3cm].



Picture 7: CECT axial image shows CT-Omental rim sign as depicted by white outline in biopsy proven case of peritoneal tuberculosis.

PROFORMA

S.No. MRD No.

Name Age/Sex

Address

Contact No.

Chief Complaints :-

- Fever
- Vomitting
- Pain Abdomen
- Loss of appetite
- Loss of weight
- Abdominal distension
- Cough
- Bowel habits
- Any other complaints

Past Medical/ surgery History

Generalised physical examination

Clinical Diagnosis

Lab Investigation

- Hemogram:- TLC
  HB
  Platelets
- LFTs:- SGOT
  SGPT
  Total Bilirubin
- RFTs:- Urea
  Creatinine
- ESR
- CBNAAT(if done)
- Chest Xray

Signature of Candidate

Signatureof Supervisor

- Ultrasound (if done)

- Biochemical Examination (if done) : - S. LDH
  - S. ADA
- Analysis of Ascitic Fluid:
  -Cytology for malignant cells
  -ADA (if done)
  -LDH (if done)

CECT findings

Characteristics	Category
Omental Thickening	Smudgy Cake like Nodular
Peritoneal Thickening	Absent Diffuse-smooth Irregular/nodular
Peritoneal nodule types	Micro-nodules (<5mm) Macro-nodules (>5mm) Mixed
Peritoneal nodular enhancement	Homogenous Heterogenous
Mesenteric Thickening	Absent Present
Mesenteric nodules	Absent Micro Macro Mixed
Ascites presence and type	Absent Free Loculated
Ascites quantity	Absent Mild (Only in pelvis) Moderate (In pelvis and abdomen with max depth of 3cm) Large (Bulging flanks with measurable depth >3cm)
Ascites density	Hyperdense (>10HU)

Signature of Candidate

Signatureof Supervisor

	Hypodense (<10HU)
Retroperitoneal nodes	Absent If Present :- Necrosis Homogenous Calcification
Mesenteric nodes	Absent If Present :-Necrosis Homogenous Calcification
Periportal/Peripancreatic nodes	Absent Necrosis Homogenous Calcification
Ovarian volume	
Omental Rim Sign	

FNAC/Biopsy (if done)

Signature of Candidate

Signatureof Supervisor

Sr. No.	MRD No	Age	Sex	Chief Complaints									Past Medical/ surgery History	Generalised physical examination	TLC	HB
				• Fever	• Vomitting	• Pain Abdomen	• Loss of appetite	• Loss of weight	• Abdominal distension	• Cough	• Bowel habits	• Any other complaints				
1	1252010	32yr	female	absent	present	present	present	present	present	absent	altered	absent	hypothyroidism	tense abdomen	7.7	12.6
2	1125170	37yr	male	present	present	absent	present	present	absent	absent	constipation	absent	absent	WNL	15.5	14.6
3	1036158	39yr	female	absent	absent	mild	present	present	present	absent	constipation	absent	absent	tense abdomen	13.7	8.3
4	1129744	63yr	female	absent	absent	present	present	present	present	absent	normal	absent	hypertension	tense abdomen	4.8	9.8
5	1171962	47yr	female	present	absent	mild	present	present	absent	present	normal	absent	absent	WNL	6.1	10.2
6	1244966	56yr	female	absent	absent	mild	present	present	present	absent	constipation	yellow discolouration of skin	absent	tense abdomen	9.9	8.8
7	1223395	49yr	female	absent	absent	on and off	present	present	present	present	normal	absent	absent	tense abdomen	10.2	7.8
8	1141839	60yr	female	absent	absent	present	absent	absent	present	absent	normal	absent	absent	tense abdomen	9.9	10.2
9	1036658	44yr	female	absent	absent	present	absent	absent	absent	absent	normal	abdominal heaviness	absent	WNL	5.7	10.4
10	1095262	23yr	female	present	absent	mild	present	absent	absent	present	altered	absent	absent	WNL	18.2	9.5
11	1191834	40yr	female	present	absent	absent	present	present	absent	present	normal	absent	migraine	tense abdomen	7.8	11
12	1050816	61yr	male	absent	present	present	present	absent	present	absent	constipation	absent	absent	WNL	9.4	12.1
13	1017088	75yr	female	present	absent	present	present	present	present	present	constipation	abdominal heaviness	absent	tense abdomen	10.7	12.9
14	1112155	39yr	female	present	nausea	present	present	present	present	absent	altered	abdominal heaviness	absent	tense abdomen	40,000	11.4
15	1112170	16yr	male	absent	absent	absent	present	present	absent	present	normal	absent	absent	WNL	11.4	4.7
16	248440	65yr	female	on and off	absent	mild	present	absent	present	on and off	normal	absent	sion,T2DM,CAD,hypotl	tense abdomen	11.3	11.1
17	1029351	16yr	female	present	absent	absent	present	present	absent	present	normal	absent	absent	WNL	10.9	12.9
18	1128301	23yr	male	present	absent	absent	present	present	absent	mild	normal	absent	absent	tense abdomen	6.4	13.4
19	968811	55yr	male	present	absent	absent	present	present	present	present	constipation	absent	absent	tense abdomen	5.8	12.2
20	1125800	64yr	male	present	absent	present	present	present	present	present	normal	absent	absent	tense abdomen	7.5	12.5
21	1046530	69yr	female	absent	absent	mild	present	present	present	absent	altered	absent	absent	tense abdomen	3.4	7.3
22	979634	17yr	female	present	absent	present	present	present	absent	present	normal	absent	absent	WNL	9.7	8.2
23	1035622	40yr	female	absent	absent	mild	present	present	present	absent	altered	absent	absent	tense abdomen	9	11
24	1113566	50yr	female	absent	absent	mild	present	present	present	mild	constipation	abdominal heaviness	absent	tense abdomen	6.4	9.3
25	1225425	69yr	female	absent	absent	present	present	present	present	absent	normal	absent	absent	WNL	6.5	12.5
26	1345664	60yr	female	absent	absent	absent	present	present	present	absent	altered	absent	absent	WNL	7.1	12
27	1361941	41yr	female	absent	absent	absent	present	absent	absent	absent	constipation	absent	absent	WNL	10.2	11
28	1376080	77yr	female	absent	absent	present	present	present	present	present	constipation	absent	absent	WNL	6.2	12.5
29	1195410	45yr	male	absent	absent	absent	absent	present	absent	absent	normal	absent	absent	WNL	7.7	7.8
30	1268160	40yr	female	present	absent	absent	present	absent	present	absent	normal	absent	absent	tense abdomen	2.6	10.9
31	1144188	50yr	male	present	absent	absent	present	present	present	mild	altered	absent	absent	tense abdomen	16.4	11.3
32	1327407	26yr	male	present	absent	absent	present	present	absent	present	normal	absent	absent	WNL	4.9	11.7
33	1334268	66yr	female	absent	absent	absent	present	present	absent	absent	normal	absent	hypertension	WNL	4.4	7.9
34	1118007	35yr	male	present	absent	absent	present	present	absent	mild	normal	absent	absent	WNL	15.8	9.3
35	985844	44yr	male	absent	absent	absent	absent	present	present	absent	normal	abdominal heaviness	absent	WNL	7.7	11.4

		Lab Investigation												o Analysis of Ascitic Fluid										
																	Omental Thickening			Peritoneal Thickening			neal nodul	
Sr. No.	MRD No	Platelets	SGOT	SGPT	Total Bilirubin	Urea	Creatinine	ESR	CBNAAT(if done)	Chest Xray	Ultrasound (if done)	S. LDH	S. ADA	Cytology for malignant cells	ADA (if done)	LDH (if done)	Smudgy	Cake like	Nodular	Absent	Diffuse-smooth	Irregular/ nodular	Micro-nodules (<5mm)	
1	1252010	2,37,000	155	116	0.46	13	0.54	15	negative	-	-	-	32.3	negative	-	-	-	+	-	-	-	+	-	
2	1125170	2,84,000	28	63	1.41	32	0.75	13	negative	-	ht side pleu	-	-	atypical cells	-	-	-	-	+	-	-	+	-	
3	1036158	2,12,000	13	10	0.6	28	0.77	6	-	normal	-	175	-	-	-	-	-	-	+	-	-	+	-	
4	1129744	2,87,000	31	42	0.73	21	0.61	-	-	normal	-	-	-	-	-	-	-	-	+	-	-	+	+	
5	1171962	4,61,000	45	41	0.44	7	0.51	-	positive	-	bowel loop	184	35.3	-	-	-	+	-	-	-	+	-	+	
6	1244966	4,05,000	159	94	9.73	16	0.53	-	-	-	ous mass in	-	29.2	-	-	-	-	-	+	-	-	+	-	
7	1223395	1,58,000	22	10	0.22	20	0.59	-	negative	-	-	-	32.6	-	-	-	+	-	-	-	-	+	-	
8	1141839	3,55,000	62	33	0.4	13	0.39	-	-	-	pelvis,chol	1315	-	negative	-	-	-	-	+	-	-	+	-	
9	1036658	1,61,000	34	37	0.15	13	0.65	-	-	normal	-	-	-	-	-	-	+	-	-	-	-	+	-	
10	1095262	1,78,000	11	6	0.58	69	0.62	120	-	-	enomegaly	321	-	-	-	-	-	-	+	-	-	+	+	
11	1191834	3,17,000	33	21	1.13	24	0.7	65	-	-	-	140	-	negative	-	-	+	-	-	-	+	-	+	
12	1050816	3,12,000	49	76	0.61	30	0.76	53	-	-	s with pros	-	-	negative	-	-	-	+	-	-	-	+	-	
13	1017088	2,56,000	16	9	0.33	18	0.91	28	negative	-	ntal thicken	180	26.7	atypical cells	-	-	-	-	+	-	-	+	-	
14	1112155	10,72,000	12	9	0.91	16	0.38	-	negative	-	normal	-	12.79	negative	-	-	-	+	-	-	+	-	+	
15	1112170	1,74,000	55	20	0.88	14	0.11	10	positive	s in bilatera	n dilated bo	260	-	-	-	-	-	+	-	-	+	-	+	
16	248440	4,40,000	17	19	0.32	93	1.31	61	negative	-	epatomega	546	-	positive for malignant cells	-	1661	-	-	+	-	-	+	-	
17	1029351	1,53,000	48	58	2.26	16	0.32	12	-	-	-	248	-	-	-	-	+	-	-	-	+	-	+	
18	1128301	3,25,000	25	14	0.72	13	0.77	7	negative	-	nd renal pa	-	87	-	-	-	+	-	-	-	+	-	-	
19	968811	2,31,000	22	11	0.47	18	0.56	82	-	pleural eff	-	-	24.3	-	-	-	+	-	-	-	-	+	+	
20	1125800	3,47,000	26	28	0.85	109	1.75	34	negative	-	rade-1 with	-	163.7	negative	-	-	-	-	+	-	+	-	-	
21	1046530	3,12,000	24	7	0.26	197	5.69	-	negative	-	-	-	-	-	-	-	-	-	+	-	-	+	-	
22	979634	6,99,000	17	18	0.39	21	0.36	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	+	
23	1035622	3,83,000	19	13	0.48	21	0.72	93	negative	-	-	-	38.2	-	-	-	-	-	+	-	+	-	+	
24	1113566	4,02,000	27	22	0.82	14	0.61	-	-	-	-	192	-	consistent with pseudomyxoma	-	-	+	-	-	-	-	+	-	
25	1225425	1,68,000	48	16	0.14	22	1.19	-	negative	-	-	258	49.5	-	-	-	-	-	+	-	-	+	-	
26	1345664	3,67,000	21	13	0.38	12	0.49	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	
27	1361941	5,21,000	26	13	0.47	31	0.5	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	
28	1376080	2,23,000	27	31	0.71	61	1.21	81	-	-	l changes v	-	-	-	-	-	-	-	+	-	-	+	-	
29	1195410	2,17,000	45	10	0.69	71	5.49	-	negative	-	te ascites v	257	119	-	-	-	-	-	+	-	+	-	+	
30	1268160	1,50,000	29	16	0.64	15	0.45	51	-	-	-	-	-	-	-	-	+	-	-	-	+	-	+	
31	1144188	6,36,000	39	6	0.51	42	0.76	32	negative	-	-	-	40.5	negative	-	-	+	-	-	-	+	-	+	
32	1327407	1,95,000	69	93	0.5	12	0.6	12	positive	-	-	-	-	-	265	118	+	-	-	-	+	-	+	
33	1334268	30,000	19	12	0.43	12	0.66	-	-	-	ckening wi	-	-	positive for malignant cells	-	-	-	+	-	-	-	+	-	
34	1118007	2,27,000	30	16	0.8	55	1.08	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	
35	985844	5,27,000	35	22	0.51	48	0.81	-	-	normal	-	-	-	-	-	-	+	-	-	-	+	-	+	

		CECT findings																							
		e types		Peritoneal nodular enhancement		esenteric Thickeni		Mesenteric nodules				Ascites presence and type			Ascites quantity				Ascites density		Retroperitoneal nodes				
																						If Present			
Sr. No.	MRD No	Macro-nodules (>5mm)	Mixed	Homogenous	Heterogenous	Absent	Present	Absent	Micro	Macro	Mixed	Absent	Free	Loculated	Absent	Mild (Only in pelvis)	Moderate (In pelvis and abdomen with max depth of 3cm)	Large (Bulging flanks with measurable depth >3cm)	Hyperdense (>10HU)	Hypodense (<10HU)	Absent	Necrosis	Homogenous	Calcification
1	1252010	-	+	+	-	+	-	+	-	-	-	-	+	-	-	-	-	+	+	-	-	-	+	-
2	1125170	-	+	-	+	+	-	-	-	+	-	-	+	-	-	+	-	-	+	-	+	-	-	-
3	1036158	-	+	-	+	-	+	-	-	-	+	-	+	-	-	-	+	-	-	+	+	-	-	-
4	1129744	-	-	-	+	-	+	-	-	-	+	-	+	-	-	-	-	+	+	-	-	-	+	-
5	1171962	-	-	+	-	-	+	-	-	-	+	-	+	-	-	+	-	-	-	+	-	+	-	-
6	1244966	-	+	-	+	-	+	-	-	-	+	-	+	-	-	-	-	+	+	-	+	-	-	-
7	1223395	+	-	-	+	-	+	-	-	-	+	-	+	-	-	-	-	+	-	+	-	-	+	-
8	1141839	-	+	-	+	-	+	-	-	+	-	-	-	+	-	-	-	+	-	+	-	-	+	-
9	1036658	-	+	-	+	-	+	-	-	-	+	-	+	-	-	+	-	-	+	-	+	-	-	-
10	1095262	-	-	-	+	-	+	-	-	+	-	-	+	-	-	+	-	-	-	+	-	+	-	-
11	1191834	-	-	+	-	-	+	-	+	-	-	-	+	-	-	-	+	-	+	-	+	-	-	-
12	1050816	-	+	-	+	+	-	+	-	-	-	-	-	+	-	-	+	-	+	-	+	-	-	-
13	1017088	-	+	-	+	-	+	-	+	-	-	-	-	+	-	-	-	+	-	+	+	-	-	-
14	1112155	-	-	+	-	-	+	-	+	-	-	-	+	-	-	-	+	-	+	-	+	-	-	-
15	1112170	-	-	+	-	-	+	-	-	+	-	-	+	-	-	+	-	-	+	-	-	-	+	-
16	248440	-	+	-	+	-	+	-	-	-	+	-	+	-	-	-	-	+	+	-	-	-	+	-
17	1029351	-	-	+	-	-	+	-	+	-	-	-	-	+	-	+	-	-	-	+	+	-	-	-
18	1128301	+	-	+	-	-	+	-	-	+	-	-	+	-	-	-	-	+	+	-	-	-	+	-
19	968811	-	-	-	+	-	+	-	+	-	-	-	+	-	-	-	-	+	+	-	+	-	-	-
20	1125800	+	-	+	-	-	+	-	-	+	-	-	+	-	-	-	-	+	-	+	-	-	+	-
21	1046530	+	-	+	-	-	+	-	-	+	-	-	+	-	-	-	-	+	-	+	+	-	-	-
22	979634	-	-	+	-	-	+	-	-	+	-	-	+	-	-	+	-	-	+	+	+	-	-	-
23	1035622	-	-	+	-	+	-	-	+	-	-	-	+	-	-	-	-	+	-	+	+	-	-	-
24	1113566	-	+	-	+	+	-	-	+	-	-	-	+	-	-	-	-	+	+	-	+	-	-	-
25	1225425	-	+	+	-	-	+	-	-	-	+	-	-	+	-	-	+	-	+	-	-	-	+	-
26	1345664	-	+	+	-	+	-	+	-	-	-	-	-	+	-	-	+	-	-	+	+	-	-	-
27	1361941	-	-	+	-	-	+	-	-	-	+	-	+	-	-	+	-	-	+	-	-	-	+	-
28	1376080	-	+	+	-	-	+	-	-	-	+	-	-	+	-	-	+	-	+	-	+	-	-	-
29	1195410	-	-	+	-	-	+	-	-	-	+	-	-	+	-	+	-	-	+	-	+	-	-	-
30	1268160	-	-	+	-	+	-	+	-	-	-	-	-	+	-	-	-	+	+	-	+	-	-	-
31	1144188	-	-	+	-	-	+	-	+	-	-	-	+	-	-	-	-	+	+	-	+	-	-	-
32	1327407	-	-	+	-	-	+	-	-	-	+	-	+	-	-	-	+	-	+	-	+	-	-	-
33	1334268	-	+	+	-	-	+	-	-	-	+	-	-	+	-	+	-	-	-	+	+	-	-	-
34	1118007	-	-	-	-	+	-	-	-	-	+	-	-	+	-	+	-	-	+	-	+	-	-	-
35	985844	-	-	+	-	-	+	-	-	-	+	-	+	-	-	-	+	-	-	+	+	-	-	-

		Mesenteric nodes				Periportal/Peripancreatic nodes				Ovarian volume								
			If Present				If Present				right ovary		left ovary					
Sr. No.	MRD No	Absent	Necrosis	Homogenous	Calcification	Absent	Necrosis	Homogenous	Calcification	<10cc	10-15cc	>15cc	<10cc	10-15cc	>15cc	Omental Rim Sign	FNAC/Biopsy (if done)
1	1252010	+	-	-	-	+	-	-	-	+	-	-	+	-	-	absent	carcinoma
2	1125170	-	-	+	-	+	-	-	-	-	-	-	-	-	-	absent	metastatic carcinomatous deposits
3	1036158	-	-	+	-	+	-	-	-	+	-	-	+	-	-	present	malignant neoplasm possibly poorly differentiated carcinoma-caecum
4	1129744	-	+	-	-	+	-	-	-	-	-	+	-	-	+	absent	malignancy (omentallesion)
5	1171962	-	-	+	-	+	-	-	-	+	-	-	+	-	-	absent	granulomatous inflammation possibly TB
6	1244966	-	-	+	-	-	+	-	-	+	-	-	+	-	-	absent	metastatic mucin secreting adenocarcinomatous deposits
7	1223395	-	-	+	-	-	-	+	-	-	-	+	-	-	+	absent	metastatic carcinomatous deposits
8	1141839	-	-	+	-	+	-	-	-	-	-	-	-	-	-	absent	carcinoma
9	1036658	-	-	+	-	+	-	-	-	-	-	+	-	-	+	absent	serous carcinoma
10	1095262	-	+	-	-	-	+	-	-	+	-	-	+	-	-	absent	non-hodgkin lymphoma
11	1191834	-	-	+	-	+	-	-	-	-	-	+	-	-	+	present	tuberculosis
12	1050816	+	-	-	-	+	-	-	-	-	-	-	-	-	-	absent	metastatic carcinomatous deposits
13	1017088	-	-	+	-	+	-	-	-	-	-	-	-	-	-	absent	mucinous carcinoma
14	1112155	-	-	+	-	+	-	-	-	+	-	-	-	-	+	absent	mature cystic teratoma
15	1112170	-	-	+	-	-	-	+	-	-	-	-	-	-	-	present	tuberculosis
16	248440	-	-	+	-	-	-	+	-	-	-	+	-	-	+	absent	adenocarcinoma
17	1029351	-	+	-	-	+	-	-	-	+	-	-	+	-	-	present	tuberculosis
18	1128301	-	-	+	-	-	-	+	-	-	-	-	-	-	-	absent	chronic inflammatory infiltrate
19	968811	-	-	+	-	+	-	-	-	-	-	-	-	-	-	absent	signet ring cell gastric carcinoma
20	1125800	-	-	+	-	+	-	-	-	-	-	-	-	-	-	present	tuberculosis
21	1046530	-	-	+	-	+	-	-	-	+	-	-	-	+	-	absent	tuberculosis
22	979634	-	+	-	-	-	+	-	-	+	-	-	+	-	-	absent	granulomatous inflammation
23	1035622	-	-	+	-	+	-	-	-	+	-	-	+	-	-	absent	metastatic carcinomatous deposits
24	1113566	-	-	+	-	+	-	-	-	+	-	-	-	-	+	absent	mucinous carcinoma one side tubo-ovarian mass and low grade mucinous neoplasm appendix
25	1225425	-	-	+	-	-	-	+	-	+	-	-	+	-	-	absent	metastatic adenocarcinomatous deposits
26	1345664	+	-	-	-	+	-	-	-	+	-	-	+	-	-	absent	serous carcinoma
27	1361941	-	-	+	-	+	-	-	-	-	-	+	-	-	+	absent	metastatic carcinomatous deposits
28	1376080	-	-	+	-	+	-	-	-	+	-	-	+	-	-	absent	metastatic carcinomatous deposits
29	1195410	-	+	-	-	+	-	-	-	-	-	-	-	-	-	present	tuberculosis
30	1268160	+	-	-	-	+	-	-	-	+	-	-	+	-	-	absent	chronic ischemic pathology
31	1144188	-	-	+	-	+	-	-	-	-	-	-	-	-	-	absent	tuberculosis
32	1327407	-	+	-	-	+	-	-	-	-	-	-	-	-	-	absent	tuberculosis
33	1334268	-	-	+	-	+	-	-	-	-	-	-	-	-	-	present	high grade serous carcinoma
34	1118007	-	-	+	-	-	+	-	-	-	-	-	-	-	-	absent	tuberculosis
35	985844	-	-	+	-	+	-	-	-	-	-	-	-	-	-	absent	tuberculosis

No. BFUHS/2K21p-TH/ 1871

Date 28/10/21

The Principal,
DMC, Ludhiana.

Subject: **Approval of Plan of Thesis.**

This is to inform you that the Faculty of Medical Sciences in its meeting held on 29.10.2021 has approved the plan of thesis of **Navjot Singh**, a student of your college for **MD Radio-diagnosis** along with the names of Supervisor/Co-Supervisor as under:-

Topic Plan of Thesis
Role of multi-detector contrast enhanced ct in peritoneal diseases.

Supervisor
Dr. Kamini Gupta
Prof.,
Dept. of Radio-diagnosis,
DMCH, Ludhiana.

Co-Supervisor

Dr. Archana Ahluwalia
Prof.,
Dept. of Radio-diagnosis,
DMCH, Ludhiana.

The student has to submit the four copies of thesis (along with PDF format) , to the Controller of Examinations, BFUHS, Faridkot, at least six months before the commencement of theory examination, if he/she is otherwise eligible to take the examination. He /She must directed to attach a photocopy of this letter with the forwarding letter while submitting thesis to the University along with the letter of approval of University for change of supervisor/Co-Supervisor, change of topic,(if any).

Dr. S P Singh MS(Oph)
Controller of Examinations

Note :

117. If any discrepancy found regarding topic of thesis or Supervisor/Co-Supervisor, inform undersigned within one month after issue of this letter.

118. The student may submit the thesis as per the schedule already conveyed i.e for May/June examination 30th Nov of the preceding the year of examination and for Nov/Dec examinations 31st May of the year of examination.

ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES

THESIS PROPOSAL

FOR APPROVAL OF SUBJECT OF THESIS TO BE SUBMITTED IN

PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

Doctor of Medicine

in

RADIODIAGNOSIS

OF THE

BABA FARID UNIVERSITY OF HEALTH SCIENCES

FARIDKOT

March, 2021

DR. NAVJOT SINGH

DEPARTMENT OF RADIODIAGNOSIS
DAYANAND MEDICAL COLLEGE AND HOSPITAL
LUDHIANA

ABSTRACT OF PLAN OF THESIS

Title	ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES
For the degree of	Radiodiagnosis
Name of the candidate	Dr. Navjot Singh
Supervisor	Dr. Kamini Gupta, Professor, Department of Radiodiagnosis, DMCH, Ludhiana
Co-supervisors	Dr. Archana Ahluwalia, Professor, Department of Radiodiagnosis, DMCH, Ludhiana
Institution	Dayanand Medical College & Hospital, Ludhiana
University	Baba Farid University of Health Sciences, Faridkot

Introduction: Peritoneal diseases includes peritoneal carcinomatosis, peritoneal tuberculosis, pseudomyxoma peritonei, peritoneal mesothelioma, lymphoma and infective/ inflammatory peritonitis.

OnMulti-detector contrast enhanced CT, normal peritoneum is a thin membrane and is hardly noticeable .The involvement of peritoneum in various diseases causes its thickening which become easily detectable on cross-sectional imaging.

Most of the peritoneal diseases have similar CT appearance, however based on certain CT patterns, benign peritoneal diseases can be differentiated from malignant ones and underlying pathology may be defined.

Aims & Objectives: 1.To assess the role of multi detector contrast enhanced CT in evaluation of peritoneal diseases.

2. To predict the etiology of peritoneal diseases and correlate with histopathology, wherever possible.

Materials and methods: A prospective study of patients undergoing multi-detector contrast enhanced CT for peritoneal disease, at the Department of Radiodiagnosis, Dayanand Medical College &Hospital, during a period of one year.

Clinical significance: To determine the etiology of peritoneal diseases based on various CT features and participate in clinical management.

Keywords: Multi-detector Contrast enhanced Computed Tomography (CECT), Peritoneal carcinomatosis(PC),Peritoneal tuberculosis(PTB).

Navjot Singh.

(signature) Candidate

(signature) Co-supervisor

(signature) Supervisor

(signature) Principal

CERTIFICATE OF FACILITIES AVAILABLE

This is to certify that the facilities for work on the subject of thesis titled **"ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES"** exist in the Department of Radiodiagnosis, DMC&H, Ludhiana and will be provided to the candidate. We will see that the data being included in the thesis is genuine and is collected by the candidate herself under our supervision and guidance.

Supervisor

Dr. Kamini Gupta
Professor
Department of Radiodiagnosis
DMCH, Ludhiana

Co-Supervisor

Dr Archana Ahluwalia
Professor
Department of Radiodiagnosis
DMCH, Ludhiana

Head of the Department

Dr. Kavita Saggar
Professor & Head
Department of Radiodiagnosis
DMCH, Ludhiana

Place: DMCH, Ludhiana

Date: 17/3/21

APPROVAL PROFORMA
BY
RESEARCH & ETHICAL COMMITTEE
DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA

Name of candidate	Dr. Navjot Singh
Department	Radiodiagnosis
Topic of Thesis	ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES
Likely date of appearing in PG examination	May-June 2022
Date of enrollment	30th June 2020
Name of Head of Department	Dr. Kavita Saggar
1) Supervisor **2) Co-Supervisor**	Dr. Kamini Gupta Dr. Archana Ahluwalia
Signature of Members of Research Committee with Stamp	**Signature of Members of Ethics Committee with Stamp**
Dr. Harpreet Kaur (Professor & Head, Pathology)	Mr. R K Sharma (Legal Expert)
Dr. Jaspal Singh (Professor & Head, Surgery)	Dr. Ramit Mahajan (Associate Professor, Gastroenterology)
Dr. Dinesh Gupta (Professor & Head, Medicine)	Dr. Anu Sharma (Professor, Anatomy)
Dr. Sandeep Kaushal (Dean Academics & Professor & Head, Pharmacology)	Dr. Sandeep Kaushal (Dean Academics & Professor & Head, Pharmacology)
Dr. Gurpreet S Wander (Vice Principal)	Dr. Gurpreet S Wander (Vice Principal & Professor & Head, Cardiology)
	Dr. Gagandeep Singh (Secretary, Ethics Committee Professor & Head, Neurology)

Approved: Yes / No

Dr. Sandeep Puri
Chairperson
Research Committee

Approved: Yes / ~~No~~

Prof. Arvind Malhotra
Chairperson
Ethics Committee

BABA FARID UNIVERSITY OF HEALTH SCIENCES, FARIDKOT

PROFORMA FOR REGISTRATION OF SUBJECT FOR DISSERTATION

1	NAME OF THE CANDIDATE AND ADDRESS	Dr. Navjot Singh, R/o H.No 841 Street No 8 Tafazalpura colony Patiala
2	NAME OF THE INSTITUTE	Dayanand Medical College and Hospital, Ludhiana
3	COURSE OF STUDY AND SUBJECT	M.D. Radiodiagnosis
4	DATE OF ADMISSION OF COURSE	30/06/2020
5	TITLE OF THE TOPIC	ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES

6. BRIEF RESUME OF THE INTENDED WORK

6.1 NEED FOR THE STUDY

The peritoneum is a mesothelial lining covering the abdominal cavity (parietal peritoneum) and intraperitoneal organs (visceral peritoneum). Peritoneal cavity contains a small amount of fluid, which circulates under the influence of negative pressure generated by the diaphragm, gravity and bowel peristalsis. This natural flow pattern determines the route of spread of disease processes within the peritoneal cavity.[1,2]

Common peritoneal diseases in India includes peritoneal carcinomatosis and peritoneal tuberculosis.

Peritoneal carcinomatosis (PC) is defined as intraperitoneal dissemination of any tumor which is not originated from the peritoneum itself.[3]

On Multi-detector contrast enhanced CT, normal peritoneum is a thin membrane and is hardly noticeable. The involvement of peritoneum in various diseases causes its thickening which become easily detectable on cross-sectional imaging.

Most of the peritoneal diseases have similar CT appearance, however based on certain CT patterns, benign peritoneal diseases can be differentiated from malignant ones and underlying pathology may be defined.

Peritoneal carcinomatosis (PC) is most commonly seen in abdominopelvic malignancies. Ovarian cancer is the most commonest abdominopelvic malignancy with peritoneal disease with approximately 70% of patients having peritoneal involvement at the time of diagnosis. It is followed by colorectal carcinoma (31%), pancreatic cancer and stomach cancer. Other malignancies include the hepatocellular carcinoma, gallbladder carcinoma, renal cell carcinoma, transitional cell carcinoma, endometrial and cervical cancers. Extra-abdominal malignancies such as carcinoma breast, carcinoma lung and malignant melanoma involve the peritoneal cavity through the haematogenous spread.[2,4] Characterization of different CT patterns of peritoneal carcinomatosis is also important as there is predilection

of different malignancies for having different patterns of peritoneal disease.[5-7]

Many non-neoplastic and other neoplastic conditions may mimic Peritoneal carcinomatosis (PC), such as tuberculosis, splenosis implant, peritoneal lymphomatosis, pseudomyxoma peritonei and primary peritoneal mesothelioma.[3,8]

Peritoneal carcinomatosis (PC) have multiple manifestations on CT including fibronodular stranding, nodules, plaques, masses and mesenteric thickening which may produce a pleated or stellate pattern.[9] The imaging patterns of diffuse malignant peritoneal mesothelioma include thickening of the pleura, peritoneum/mesentery, nodules of various sizes and shapes, mesenteric or omental infiltrations, omental cake, ascites, bone destruction, and lymphadenopathy.[10]

Tuberculosis (TB) is one of the world's deadliest diseases and peritoneal tuberculosis (PTB) is one of the commonest manifestations of abdominal TB.[11,12]

The common occurrence of mesenteric micro- or macro-nodules in the tuberculous peritonitis appears to be because tuberculous peritonitis develops from rupture of mesenteric lymph nodes seeded by the hematogenous or lymphatics routes from the primary lesion sites.[13]

Peritoneal TB is a close mimic of peritoneal carcinomatosis and it can be challenging to differentiate the two clinically as well as on imaging.[14]

Multi-detector CT with multi-planar reformation allows accurate assessment of the complex anatomy of the peritoneal cavity and helps in understanding the pathologic processes.

However, CT still poses problems, such as low sensitivity for detecting minimal peritoneal disease, especially when the lesions are less than 1 cm in diameter.[15]

Appropriate determination of extent of peritoneal disease changes the staging of disease, treatment plan and prognosis. [2]

Though the imaging features of peritoneal diseases overlap, MDCT is currently a useful tool to assess the extent of peritoneal disease and to differentiate benign from malignant diseases.

6.2 REVIEW OF LITERATURE

H K Ha et al (1996) retrospectively reviewed CT scans in 135 patients of tuberculous peritonitis (n=42) and peritoneal carcinomatosis (n=93) with documented omental, mesenteric, or peritoneal pathology. CT findings were evaluated in each group of patients for the morphologic appearance of mesenteric or omental abnormalities as well as for visualization of the spleen and liver, the lymph nodes, and ascites. Statistical comparisons were performed to adjust for the differences in CT findings between the two groups. Using multivariate analysis, they calculated the sensitivity of CT for predicting tuberculosis peritonitis and peritoneal carcinomatosis as 69% and 91% respectively.[16]

E Rodríguez et al (1996) performed a retrospective study to review the CT scans in 19 patients known to have PTB and compared with scans in 19 patients known to have PC. CT images were evaluated for thickening (smooth versus irregular), enhancement, presence of nodules, and site of involvement on the parietal peritoneum, existence of omental caking, nodules, and smudged patterns in the omentum, mesentery, and gastrocolic ligament, presence, distribution, and loculation of ascites were evaluated. The most useful CT findings for distinguishing PTB from PC were observed in the parietal peritoneum. The presence of a smooth peritoneum with minimal thickening and pronounced enhancement suggested PTB, whereas nodular implants and irregular peritoneal thickening suggested PC. [17]

Aphinya Charoensak et al (2012) studied abdominal CT scan in proven cases of TB peritonitis and P.C. retrospectively. CT findings were assessed for ascites, abnormalities of peritoneum, omentum, and mesentery, abdominal lymphadenopathy. Statistical differences of CT findings between two diseases were analyzed using Chi-square or Fisher's exact test. Smooth and uniform peritoneal thickening was more frequently seen in tuberculous peritonitis ($p < 0.001$), but irregular peritoneal thickening and peritoneal nodules were more frequently seen in peritoneal carcinomatosis ($p < 0.001$). Type of omental abnormalities significantly differed between two diseases ($p < 0.001$). Smudge type was more commonly found in tuberculous peritonitis,

while nodular and cake types were more commonly detected in peritoneal carcinomatosis. Lymph nodes size < 1 cm and location of lymph nodes at peripancreatic region were more frequently identified in tuberculous peritonitis, whereas lymph nodes size > or = 1 cm and contour abnormality of the liver or the spleen were more frequently visualized in peritoneal carcinomatosis ($p < 0.05$).[18]

A.D Diop et al (2014) analysed that Invasive peritoneal disease. Although PC the most common aetiology, especially when a primary is found, other conditions may be responsible for peritoneal invasion. A rigorous analysis of CT features taken together with the clinical and biological context usually allowed the main differential diagnoses, which entailed different types of management, to be drawn out. [3]

Alsiagy A. Salama et al (2015) studied MDCT scans of 37 patients with omental lesions after administration of oral and intravenous contrast. Sensitivity, specificity, and diagnostic accuracy of MDCT were calculated. They opined that sensitivity, specificity and diagnostic accuracy of 73%, 92%, 85% and 90%, 95%, 93%, respectively in PTB and PC. This concluded that MDCT is an excellent diagnostic tool for evaluating omental lesions.[19]

Belqees Yawar et al (2015) studied two hundred and three patients with histopathologically proven abdominopelvic malignancies with peritoneal involvement who underwent contrast-enhanced CT abdomen and pelvis**.** They concluded that peritoneal involvement is common in ovarian and colorectal carcinoma. Mixed pattern of peritoneal pattern was most frequently seen in these patients followed by omental caking and nodular peritoneal deposits. The most common sites of peritoneal involvement were pelvic peritoneum followed by greater omentum.[20]

Dr S. Subhaschandra Singh et al (2016) analysed that peritoneal involvement patterns were helpful in narrowing down the differential diagnosis of diffuse peritoneal diseases. Peritoneal carcinomatosis should be considered if ascites present with irregular peritoneal thickening, nodular omental and peritoneal deposits, omental caking. Tuberculosis can present in dry, wet or fibrotic forms and can strongly

mimic peritoneal carcinomatosis; ascites with smooth or irregular peritoneal thickening were common findings. Presence of hepatic or splenic military microabscesses, splenomegaly, inflammatory thickening of the terminal ileum and caecum and caseous lymphadenopathy in appropriate clinical scenario supported abdominal tuberculosis. [21]

Wen-jie Yin et al (2016) performed CT scans in 53 patients with malignant peritoneal mesothelioma (MPM) and 27 patients with tuberculous peritonitis (TBP) confirmed by pathology were retrospectively reviewed. The CT findings were evaluated for the morphologic appearance of ascites, peritoneum, mesenterium and omentum involvement, enlarged lymph nodes, solid abdominal viscera infiltration and metastases, and thoracic changes. Patients in both groups displayed a high proportion of peritoneum and mesenterium thickening. However, TBP showed smooth peritoneal thickening, pleural effusion, and extraperitoneal tuberculosis and MPM showed irregular thickening, omentum caking , abdominal viscera infiltration and pleural plaques.[22]

Yu-Fei Liang et al (2016) studied two groups in terms of thickness, clinical manifestation, diameter of lymph nodes, ascites, and viscera infiltration. They concluded that smooth and irregular peritoneal thickening, omental cake, mesentery involvement, location of enlarged lymph nodes in cardio-phrenic region were more seen in diffuse malignant peritoneal mesothelioma group whereas peritoneal nodules, nodular type of omentum , location of enlarged lymph nodes in retroperitoneal region, lymph nodes fusion were more commonly detected in PC group.[23]

Farah Naz et al(2018) analysed that out Of the 98 patients identified, 62(63.2%)were found to be cases of disseminated tuberculosis and 36(36.7%) were diagnosed as malignant on histopathology. Computed tomography features were significantly specific to differentiate abdominal tuberculosis from carcinomatosis (p=0.004). On computed tomography,4 findings showed statistical significance:- Smooth thickening of the peritoneum (p<0.001), abdominal mass (p=0.03),

lymph node necrosis (p=0.024) and high-density ascitic fluid (p<0.001). Out of these, smooth thickening of the peritoneum (sensitivity=77%; specificity=86.1%) and high-density ascitic fluid (sensitivity=68.9%; specificity=72.2%) were more specific findings. Overall, the sensitivity and specificity of computed tomography was found to be 88.5% and 83.3%, respectively**.** However, it concluded that no single finding on a computed tomography scan was diagnostic proof of peritoneal tuberculosis, a combination of findings could reliably distinguish between peritoneal tuberculosis and carcinomatosis.[24]

Rochita Venkata Ramanan et al (2019) studied a group of 85 patients, 52 men and 33 women, with peritoneal TB. The control group consisted of 168 consecutive patients, 96 men and 72 women, with PC. The images were analysed for omental thickening and enhancement, peritoneal thickening and nodules, mesenteric thickening and nodules, presence, quantity, loculation and density of ascites, presence of nodes, bowel and other organ involvement as well as a new sign called the CT-OR sign. The CT-OR sign could identify 85% of patients with PTB. It was absent in 96% of patients with PC and was effective in ruling out PC ($p < 0.001$). The sign had a sensitivity of 85%, specificity of 96%, positive predictive value of 92%, negative predictive value of 93% and accuracy of 92%.[25]

6.3 AIMS AND OBJECTIVES OF THE STUDY

1. To assess the role of multidetector contrast enhanced CT in evaluation of peritoneal diseases.
2. To predict the etiology of peritoneal diseases and correlate with histopathology, wherever possible.

7. MATERIALS AND METHODS

7.1 Source of Data

A prospective study of patients with peritoneal diseases undergoing multidetector contrast enhanced CT, at the Department of Radiodiagnosis, Dayanand Medical College & Hospital, during a period of one year from 1st March 2021 to 28 Feb 2022.

7.2 METHOD OF COLLECTION OF DATA

All patients with peritoneal disease on contrast enhanced CT will be included in study. Consent will be obtained from each patient and relevant detailed history will be elicited. Findings of general physical and systemic examination will be recorded. Before starting the study, the procedure will be explained to the patient in his/her vernacular language to allay the fear and anxiety. MDCT of suspected cases will be performed on Siemens 128 slice CT scan machine after giving intravenous contrast.

Inclusion criteria:

All patients found to have peritoneal disease on multi-detector contrast enhanced CT.

Exclusion Criteria:

- Any contraindications to contrast administration (GFR < 30ml/min).
- Anyone who is unwilling to participate in the study.
- Patient who are already on treatment for peritoneal disease.

Duration of study: 1 year from 1st March 2021 to 28 Feb 2022

Outcome: To analyze the CT findings in peritoneal diseases and predict their etiology and correlate with histopathology, wherever possible.

Statistical analysis: Data will be described in terms of range; mean ±standard deviation (± SD), frequencies (number of cases) and relative frequencies (percentages) as appropriate. All statistical calculations will be done using SPSS (Statistical Package for the Social Science) SPSS 21 version statistical program for Microsoft Windows.

7.3 DOES THE STUDY REQUIRE ANY INVESTIGATIONS OR INTERVENTIONS TO BE CONDUCTED ON PATIENTS OR OTHER HUMANS OR ANIMALS? IF SO, PLEASE DESCRIBE BRIEFLY.

The study will be performed on Siemens 128 slice CT scan machine after giving intravenous contrast.

However, the study does not require any intervention to be conducted on patients, other humans or animals.

7.4 HAS ETHICAL CLEARANCE BEEN OBTAINED FROM YOUR INSTITUTION IN CASE OF 7.3?

Attached herewith

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PROFORMA

S.No. MRD No.

Name Age/Sex

Address

Contact No.

Chief Complaints :-

- Fever
- Vomitting
- Pain Abdomen
- Loss of appetite
- Loss of weight
- Abdominal distension
- Cough
- Bowel habits
- Any other complaints

Past Medical/ surgery History

Generalised physical examination

Clinical Diagnosis

Lab Investigation

- Hemogram:- TLC
  HB
  Platelets
- LFTs:- SGOT
  SGPT
  Total Bilirubin
- RFTs:- Urea
  Creatinine
- ESR
- CBNAAT(if done)
- Chest Xray

Signature of Candidate

Signatureof Supervisor

- Ultrasound (if done)

- Biochemical Examination (if done) : - S. LDH
  - S. ADA
- Analysis of Ascitic Fluid:
  -Cytology for malignant cells
  -ADA (if done)
  -LDH (if done)

CECT findings

Characteristics	Category
Omental Thickening	Smudgy Cake like Nodular
Peritoneal Thickening	Absent Diffuse-smooth Irregular/nodular
Peritoneal nodule types	Micro-nodules (<5mm) Macro-nodules (>5mm) Mixed
Peritoneal nodular enhancement	Homogenous Heterogenous
Mesenteric Thickening	Absent Present
Mesenteric nodules	Absent Micro Macro Mixed
Ascites presence and type	Absent Free Loculated
Ascites quantity	Absent Mild (Only in pelvis) Moderate (In pelvis and abdomen with max depth of 3cm) Large (Bulging flanks with measurable depth >3cm)
Ascites density	Hyperdense (>10HU)

Signature of Candidate

Signatureof Supervisor

	Hypodense (<10HU)
Retroperitoneal nodes	Absent If Present :- Necrosis Homogenous Calcification
Mesenteric nodes	Absent If Present :-Necrosis Homogenous Calcification
Periportal/Peripancreatic nodes	Absent Necrosis Homogenous Calcification
Ovarian volume	
Omental Rim Sign	

FNAC/Biopsy (if done)

Signature of Candidate

Signatureof Supervisor

INFORMED PATIENT CONSENT

Date: _____

I.....D/o, W/o, S/o..... .....am willing to participate in the study **"ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES"** The procedure with its complications has been explained to me in local vernacular language. I have fully understood that no special tests and extra expenditure in any form, merely for the purpose of thesis is being carried out. I am free to opt out the study any time without assigning any reason.

....

Signature of the Witness Signature of the patient

Name:

Signature of Candidate **Signature of Supervisor**

मरीज अनुमति फार्म

तिथि _____

मैं _____ पत्नी/पुत्र/पुत्री _____ निवासी _____ इस शोधकार्य "ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES" में भाग लेने के लिए सहमत हूँ। मैं इस शोधकार्य में भाग लेने के लिए अपनी स्वेच्छा से तैयार हूँ। मैं पुष्टि करता/करती हूँ की यह स्वीकृति देने के लिए मुझे कोई आर्थिक प्रलोभन नहीं दिया गया और न ही दबाव डाला गया है। मुझे इस शोधकार्य का उद्देश्य स्पष्ट कर दिया गया है और मुझे यह विश्वास है की यह विज्ञान और मानवता के लाभ के लिए है। मुझे इस शोधकार्य में होने वाले जोखिम के बारे में समझा दिया गया है और मेरी समझ में यह जोखिम बहुत मामुली है।

मैं इस शोधकार्य में भाग लेने के सम्बन्ध में किसी भी समय अपनी अस्वीकृति व्यक्त कर सकता/सकती हूँ और मेरे अस्वीकृति व्यक्त करने का मेरे इलाज पर कोई प्रभाव नहीं पड़ेगा।

_____
गवाह के हस्ताक्षर
नाम:

_____
रोगी के हस्ताक्षर/अंगूठे का निशान
नाम:

_____
अन्वेषक के हस्ताक्षर

_____
विद्यार्थी के हस्ताक्षर

ਮਰੀਜ਼ ਰਜ਼ਾਮੰਦੀ ਫਾਰਮ

ਮਿਤੀ_____

ਮੈ_____ਪਤਨੀ/ਪੁੱਤਰ/ਪੁੱਤਰੀ_____

ਵਾਸੀ _____

"ROLE OF MULTI-DETECTOR CONTRAST ENHANCED CT IN PERITONEAL DISEASES" ਤੇ ਚਲ ਰਹੀ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਰਜ਼ਾਮੰਦ ਹਾਂ। ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਮੈ ਆਪਣੀ ਮਰਜ਼ੀ ਨਾਲ ਤਿਆਰ ਹਾਂ। ਮੈ ਇਹ ਦਸਣਾ ਚਾਹੁੰਦਾ ਹਾਂ/ ਚਾਹੁੰਦੀ ਹਾਂ ਕੇ ਇਹ ਰਜ਼ਾਮੰਦੀ ਦੇਣ ਵਾਸਤੇ ਮੈਨੂ ਕਿਸੇ ਵੀ ਤਰਾਂ ਦਾ ਲੋਭ-ਲਾਲਚ ਨਹੀ ਦਿੱਤਾ ਗਿਆ ਅਤੇ ਨਾ ਹੀ ਕੋਈ ਦਬਾ ਪਾਇਆ ਗਿਆ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਦਾ ਮਨੋਰਥ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਭਰੋਸਾ ਦਵਾਇਆ ਗਿਆ ਹੈ ਕੇ ਇਹ ਖੋਜ ਵਿਗਿਆਨ ਅਤੇ ਮਾਨਵਤਾ ਦੀ ਭਲਾਈ ਲਈ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਵਿਚ ਹੋਣ ਵਾਲੇ ਖਤਰੇ ਬਾਰੇ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਯਕੀਨ ਹੈ ਕੇ ਇਹ ਖਤਰਾ ਬਹੁਤ ਮਾਮੂਲੀ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਦਾ ਢੰਗ – ਤਰੀਕਾ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ।

ਮੈ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਬਾਰੇ ਆਪਣੀ ਰਜ਼ਾਮੰਦੀ ਕਿਸੇ ਵੀ ਸਮੇ ਵਾਪਸ ਲੈ ਸਕਦਾ ਹਾਂ/ ਸਕਦੀ ਹਾਂ ਅਤੇ ਮੇਰੀ ਰਜ਼ਾਮੰਦੀ ਵਾਪਸ ਲੈਣ ਦਾ ਮੇਰੇ ਇਲਾਜ ਤੇ ਕੋਈ ਅਸਰ ਨਹੀ ਹੋਵੇਗਾ।

_____ _____

ਗਵਾਹ ਦੇ ਹਸਤਾਖਰ ਮਰੀਜ਼ ਦੇ ਹਸਤਾਖਰ

ਮਿਤੀ_____ ਮਿਤੀ_____

ਪਤਾ _____ ਪਤਾ _____

_____

ਨਿਰੀਖਕ ਦੇ ਹਸਤਾਖਰ

_____

ਸਿਖਿਆਰਥੀ ਦੇ ਹਸਤਾਖਰ